

Dear referees prof. Mauro Zigliotto and Marco Tursini,

First of all, I would like to express my gratitude for your effort in reviewing my doctoral thesis and for the positive feedback you provided. I am glad my work was appreciated.

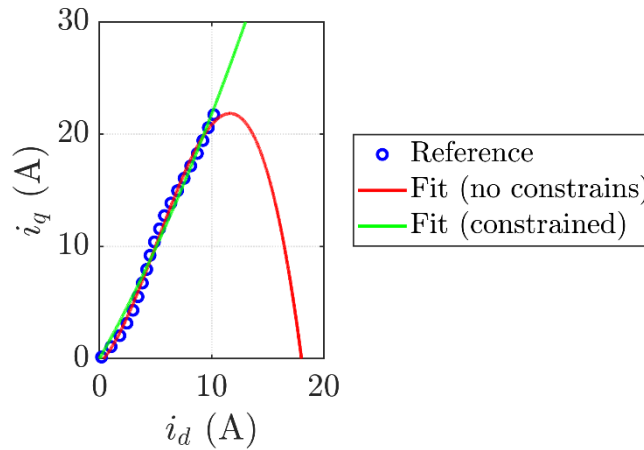
I write this document to answer to the issues highlighted by prof. Mauro Zigliotto. Each answer has a number referred to the question he expressed in the file attached to his review. I report his original file as well at the end of this letter for better clarity.

1. The manuscript was read again, doing my best to correct all the typo errors.
2. Expression (2.4) was checked, finding a sign mistake that was corrected.
3. The symbols L_d and L_q are now defined at page 26, just after their first occurrence in (2.2).
4. Equation (2.30) was corrected adopting the notation i_{dq} .
5. Actually, Figure 2.13 is intended for graphical description of the active flux concept considering the real machine flux vector and correct apparent inductance. Under these conditions, the active flux vector would perfectly fall on the d axis. Conversely, the equation (2.34) is based on the observed flux and estimated L_q , thus converging to an estimated position $\hat{\theta}^{HS}$ that may differ from the real one θ . For this reason, I preferred not to modify the Figure.
6. Paragraph 3.2.1 was omitted. The numeration of all the subsections of 3.2 was modified accordingly.
7. No, no filters were applied to the measured currents in any of the tests report in the thesis, except the removal of common mode current component, which is a common practice for control of electrical drives. In Fig. 3.2, the absence of visible current noise is due to the relatively high current respect to the inverter ratings (maximum 50 A), so the noise was small in percentage.
8. Yes, the plotted quantity is the reference voltage, as stated in the text close to the Figure: "Figure 3.2 highlights the reference voltage and measured current ...". The paragraph was rephrased to better underline this issue.
9. The rated current has been added to the caption of Fig. 3.2. Moreover, the rated current is now indicated in the captions of Figures 3.22, 3.23 and 3.24, which are plotted in the same manner for different motors.
10. The paragraph has been rephrased to improve the coherence of the text.
11. The acronym OL, which stands for Open Loop, is now defined in the Figure caption.
12. The suggested reference has been added to the manuscript.
13. The change of notation was a typo error. It has been corrected in the revised version.
14. As stated in the paragraph, there are two main methods for getting rid of the flux estimation drift. The first is to replace the open loop pure integrator with a low-pass filter having a sufficiently low cut-off frequency, not to interfere with the flux estimation. In this way, the offset of the flux characteristic is naturally driven to zero. The alternative is to consider only few square wave cycles, so that the (eventual) voltage offset is integrated for a reduced time and the flux drift is very limited. If this drift is neglected, still there is the problem of defining the initial value of the integrator. Only in this case, the flux characteristic is shifted to force zero flux at zero current. The paragraph has been rephrased to better explain the concept.

15. It is true that, generally speaking, polynomial functions may not be able to properly extend the measured data out of the measurement. As an example, monotonic reference characteristics may be approximated with a fitting function presenting undesired maximum or minimum. An example is given in the following Figure, reporting the reference MTPA (blue dots) of a SyR motor and its interpolation with a third order polynomial (red line).

$$i_{q,MTPA}^{fit} = a_3 i_d^3 + a_2 i_d^2 + a_1 i_d + a_0$$

As can be seen, even if the MTPA trajectory is always growing when increasing i_d , the fitting function presents a local maximum and starts decreasing for $i_d > 11$ A. Anyway, this problem can be solved by imposing the polynomial parameters to be non-negative, thus forcing the fitting function to be monotonic, at least for positive i_d . Although the root mean square error inside the measurement domain will be surely higher, the qualitative shape of the function is guaranteed. This has been done in the green line of the same Figure. In the same way, the analytical model presented in (3.37) can properly describe the flux maps even out of the identification measurement domain. This concept is now better clarified in the text of the manuscript, just after the model equations (page 90).



16. To better prove the accuracy of the analytical model, a new Figure 3.26(b) has been added and commented, indicating the contour of the discrepancy between reference and estimated currents. As can be seen, the maximum discrepancy in the full plane is around 0.2-0.4 A, while the rated current of that motor is 10.5 A.
17. No, the application of (3.58) does not require a special sampling. The notation $i_d(k - 0.5)$ and $i_d(k + 0.5)$ refers to the definition reported in (3.54).
18. Yes, it is correct. The only point of interest on the zero torque locus for the evaluation of λ_{pm} is its intercept with the q axis, defining i_{qT0} . The text of the paragraph has been rephrased to better clarify the concept.
19. Yes, the colors were incorrectly indicated in the caption. The mistake has been corrected.
20. The Figure has been modified adding the missing label.
21. The suggested vector notation has been adopted.
22. The acronym BSF stands for Band-Stop Filter. It is now defined in the text close to the Figure.

23. The Figure has been modified adding the MTPA trajectory and minimum flux limits.
24. The gray scale has not been added. Anyway, the values of k'_e in the dq plane are visible in the contour lines. The font of the numbers in the Figure was increased for better clarity.
25. Unfortunately, due to external constraints a proper torque meter was not available at the moment of that test, so the real torque has not been measured. Therefore, I had to rely on the observed torque. Anyway, a similar test was simulated in Figure 4.2, which shows the real motor torque. A sentence has been added to the text to explain this issue.
26. The Figure layout has been modified to solve this issue, without reducing the Figure quality. The same problem was found and solved for Figure 3.1.
27. In this test, an acceleration rate of 5000 rpm/s was adopted. Faster accelerations, although possible, showed a more noisy torque response. The point is now better detailed in the text of the manuscript, close to the Figure.
28. Yes, the hyperlink was incorrect. It has been fixed in the revised version of the manuscript.
29. Since the same layout was adopted in all the Figures 5.15-5.19, it was preferred to write the complete description of the plotted quantities only once. For doing that, a footnote has been added before Figure 5.15, detailing the content of the plots.
30. The spelling mistake has been corrected.
31. No, in this case the excitation power can either be positive or negative. In any case, the difference $P_2 - P_1$ represents the net electrical power produced by the DW generator. The concept is now better detailed in the text, close to (5.3).
32. The quality of the Figure has been improved.
33. The original Figure was incorrect, since it was referred to a different test. It has been replaced and correct.

I hope this clarifies the issues you pointed out. Thank you again for your help in improving the quality of my manuscript.

Sincerely,

Paolo Pescetto

Minor issues and questions (to be included in the final version).

1. Small typos here and there, please check.
2. Expression (2.4), please check.
3. Expression (2.2) L_d and L_q , please define them at their first occurrence.
4. Expression (2.30), maybe i_{dq} in the $-(L_{dq} i_{dq} + \dots$ term need $\wedge$ symbol.
5. Fig.2.13: $\cos$ with (2.34), maybe in the figure θ^{HS} has to be used.
6. Paragraph 3.2.1 - It may be omitted, since it is clearly out of the scope of the thesis.
7. Fig.3.2: the current waveforms are perfect, without any noise that normally affects the measurement. Was any filter applied to the real measurement, before displaying?
8. Fig.3.2: the voltage signals seem to be the reference voltages, rather than the real voltage applied to the motor. Please comment in the text.
9. Fig.3.2: please use normalised quantities. As an alternative, please indicate all of nominal values in the figure caption.
10. Expression (3.5): it is obtained by "neglecting the effects of cross-saturation", that seems to be in contradiction with the fact that the hf injection is performed to extend the text #3, which specifically deals with cross-saturation. This is mentioned in passing later on in the text (p.60). Maybe it is better to anticipate a short comment close to (3.5).
11. Fig.3.7: the in-picture legend has "OL" which is not explicitly defined. Please add it the caption - for example [...](OL, red) and [...](inj, green).
12. P.67 "Therefore, these machines commonly adopt high performance iron with low power loss rate." This is deducted by comparison with the results obtained in [40]. A positive assessment, i.e. a confirmation, can be found for example in : F. Tinazzi, P. Sandulescu, L. Peretti and M. Zigliotto, "On the true maximum efficiency operations of synchronous motor drives," 2017 IEEE 12th International Conference on Power Electronics and Drive Systems (PEDS), Honolulu, HI, 2017, pp. 1,043-1,048.
13. Just after (3.25) - please maintain the same symbols, e.g. k_p PLL.
14. Paragraph (3.4.1): the offset is subtracted to the whole curve so to get a zero crossing at zero currents. This implies that a constant offset is assumed in the whole curve. Is this assumption compatible with the procedure used to obtain the curve?
15. p.90 "[...] Moreover, the analytical functions permit to extend the magnetic characteristic out of the measurement range." This is not true, in general. Polynomial functions tends to give wrong values out of the domain in which they have been obtained.
16. Fig.3.26 gives an idea, but the percentage error is not so easy to evaluate.
17. Iron losses, expression (3.58): it seems that a special sampling of the current at time $k+0.5$ is required. This is not usual, please comment.
18. p.108: "extrapolating the trajectory to intercept the vertical axis.": the point of interest is the intersection with the q-axis, isn't it?
19. Fig.3.42: In the caption "Red: measurement points. Blue:fitting function." The colors have to be swapped.
20. Fig.3.43: Although obvious, the label of the vertical axis is missing.

21. p.123: the injected voltage is a vector in the dq plane. A more coherent notation would be $\mathbf{v}_c = u_c \cos(\omega_c t) e^{j\beta}$, which perfectly fits for the following expression (4.2).
22. Fig.4.11: "BSF" is not defined, neither in the text nor in the figure caption.
23. Fig.4.7(b): opposite to (a), neither the MTPA curve, nor $\lambda_{\min}$ are included in the figure.
24. Fig.4.9: The grey scale is missing, so it is difficult to understand the values of k'_e
25. Fig.4.26 For the sake of completeness and following the discussion in the text, the inclusion of a measurement of the real torque could help.
26. Fig.4.34: it overlaps the page number, please fix it.
27. Fig.4.35: The slope of the speed reference is the fastest that allows a flawless behaviour? Please comment the choice of the slope.
28. p.175, par.4.7.3.1: The text refers to a speed reversal, maybe the reference should be made to fig.4.38 instead of fig.4.39.
29. Fig.5.15: the legend inside the graphs should be mentioned in the figure caption (i.e. "1"= speed controlled load motor...), to help the reader in understanding the figure.
30. p.201 Please consider the use of "twin" instead of "tween".
31. Expression (5.3): Doesn't any condition apply on P1, in this case?
32. Fig.5.23: Please insert a vector-quality figure.
33. Fig.5.30: Please compare the legend with the text explanation (in the figure, speed seems not to be ramped as mentioned in the text).