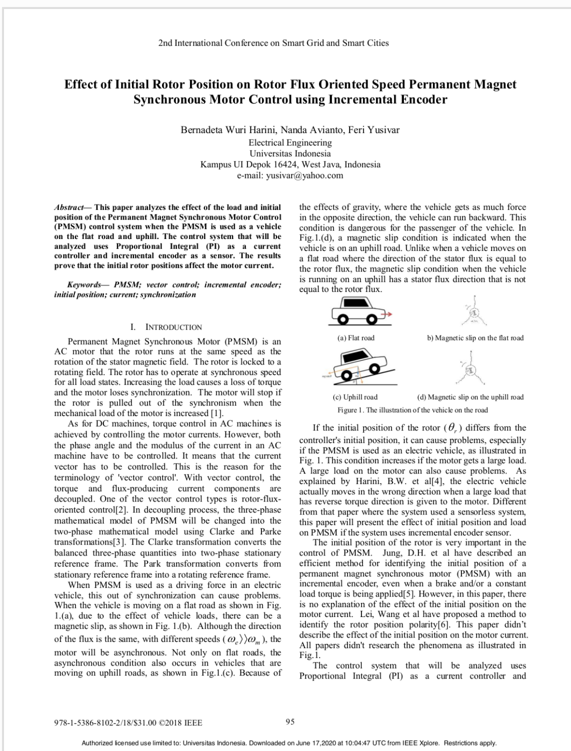
Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Bernadeta Wuri Harini
Assignment title:	Quick Submit
Submission title:	Effect of Initial Rotor Position on Rotor Flux Oriented Speed ...
File name:	Rotor_Position_on_Rotor_Flux_Oriented_Speed_Permanent_M...
File size:	3.64M
Page count:	5
Word count:	3,017
Character count:	13,957
Submission date:	11-May-2021 12:07PM (UTC+0700)
Submission ID:	1583356364



2nd International Conference on Smart Grid and Smart Cities

Effect of Initial Rotor Position on Rotor Flux Oriented Speed Permanent Magnet Synchronous Motor Control using Incremental Encoder

Bernadeta Wuri Harini, Nanda Avianto, Feri Yusivar
Electrical Engineering
Universitas Indonesia
Kampus UI Depok 16424, West Java, Indonesia
e-mail: yusivar@yahoo.com

Abstract— **This paper analyzes the effect of the load and initial position of the Permanent Magnet Synchronous Motor Control (PMSM) control system when the PMSM is used as a vehicle on the flat road and uphill. The control system that will be analyzed uses Proportional Integral (PI) as a current controller and incremental encoder as a sensor. The results prove that the initial rotor positions affect the motor current.**

Keywords— ***PMSM; vector control; incremental encoder; initial position; current; synchronization***

I. INTRODUCTION

Permanent Magnet Synchronous Motor (PMSM) is an AC motor that the rotor runs at the same speed as the rotation of the stator magnetic field. The rotor is locked to a rotating field. The rotor has to operate at synchronous speed for all load states. Increasing the load causes a loss of torque and the motor loses synchronization. The motor will stop if the rotor is pulled out of the synchronism when the mechanical load of the motor is increased [1].

As for DC machines, torque control in AC machines is achieved by controlling the motor currents. However, both the phase angle and the modulus of the current in an AC machine have to be controlled. It means that the current vector has to be controlled. This is the reason for the terminology of 'vector control'. With vector control, the torque and flux-producing current components are decoupled. One of the vector control types is rotor-flux-oriented control[2]. In decoupling process, the three-phase mathematical model of PMSM will be changed into the two-phase mathematical model using Clarke and Parke transformations[3]. The Clarke transformation converts the balanced three-phase quantities into two-phase stationary reference frame. The Park transformation converts from stationary reference frame into a rotating reference frame.

When PMSM is used as a driving force in an electric vehicle, this out of synchronization can cause problems. When the vehicle is moving on a flat road as shown in Fig. 1.(a), due to the effect of vehicle loads, there can be a magnetic slip, as shown in Fig. 1.(b). Although the direction of the flux is the same, with different speeds ($\omega_e \rangle\rangle \omega_m$), the motor will be asynchronous. Not only on flat roads, the asynchronous condition also occurs in vehicles that are moving on uphill roads, as shown in Fig.1.(c). Because of the effects of gravity, where the vehicle gets as much force in the opposite direction, the vehicle can run backward. This condition is dangerous for the passenger of the vehicle. In Fig.1.(d), a magnetic slip condition is indicated when the vehicle is on an uphill road. Unlike when a vehicle moves on a flat road where the direction of the stator flux is equal to the rotor flux, the magnetic slip condition when the vehicle is running on an uphill has a stator flux direction that is not equal to the rotor flux.

(a) Flat road b) Magnetic slip on the flat road
(c) Uphill road (d) Magnetic slip on the uphill road

Figure 1. The illustration of the vehicle on the road

If the initial position of the rotor (θ_r) differs from the controller's initial position, it can cause problems, especially if the PMSM is used as an electric vehicle, as illustrated in Fig. 1. This condition increases if the motor gets a large load. A large load on the motor can also cause problems. As explained by Harini, B.W. et al[4], the electric vehicle actually moves in the wrong direction when a large load that has reverse torque direction is given to the motor. Different from that paper where the system used a sensorless system, this paper will present the effect of initial position and load on PMSM if the system uses incremental encoder sensor.

The initial position of the rotor is very important in the control of PMSM. Jung, D.H. et al have described an efficient method for identifying the initial position of a permanent magnet synchronous motor (PMSM) with an incremental encoder, even when a brake and/or a constant load torque is being applied[5]. However, in this paper, there is no explanation of the effect of the initial position on the motor current. Lei, Wang et al have proposed a method to identify the rotor position polarity[6]. This paper didn't describe the effect of the initial position on the motor current. All papers didn't research the phenomena as illustrated in Fig.1.

The control system that will be analyzed uses Proportional Integral (PI) as a current controller and

978-1-5386-8102-2/18/$31.00 ©2018 IEEE

Authorized licensed use limited to: Universitas Indonesia. Downloaded on June 17,2020 at 10:04:47 UTC from IEEE Xplore. Restrictions apply.

Copyright 2021 Turnitin. All rights reserved.

Effect of Initial Rotor Position on Rotor Flux Oriented Speed Permanent Magnet Synchronous Motor Control using Incremental Encoder

by Harini Bernadeta Wuri

Submission date: 11-May-2021 12:07PM (UTC+0700)
Submission ID: 1583356364
File name: Rotor_Position_on_Rotor_Flux_Oriented_Speed_Permanent_Magnet.pdf (3.64M)
Word count: 3017
Character count: 13957

2nd International Conference on Smart Grid and Smart Cities

Effect of Initial Rotor Position on Rotor Flux Oriented Speed Permanent Magnet Synchronous Motor Control using Incremental Encoder

Bernadeta Wuri Harini, Nanda Avianto, Feri Yusivar
Electrical Engineering
Universitas Indonesia
Kampus UI Depok 16424, West Java, Indonesia
e-mail: yusivar@yahoo.com

***Abstract*— This paper analyzes the effect of the load and initial position of the Permanent Magnet Synchronous Motor Control (PMSM) control system when the PMSM is used as a vehicle on the flat road and uphill. The control system that will be analyzed uses Proportional Integral (PI) as a current controller and incremental encoder as a sensor. The results prove that the initial rotor positions affect the motor current.**

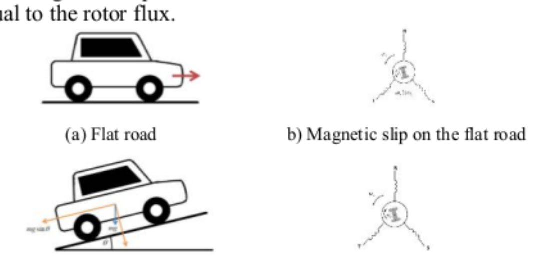
***Keywords*— PMSM; vector control; incremental encoder; initial position; current; synchronization**

I. INTRODUCTION

Permanent Magnet Synchronous Motor (PMSM) is an AC motor that the rotor runs at the same speed as the rotation of the stator magnetic field. The rotor is locked to a rotating field. The rotor has to operate at synchronous speed for all load states. Increasing the load causes a loss of torque and the motor loses synchronization. The motor will stop if the rotor is pulled out of the synchronism when the mechanical load of the motor is increased [1].

As for DC machines, torque control in AC machines is achieved by controlling the motor currents. However, both the phase angle and the modulus of the current in an AC machine have to be controlled. It means that the current vector has to be controlled. This is the reason for the terminology of 'vector control'. With vector control, the torque and flux-producing current components are decoupled. One of the vector control types is rotor-flux-oriented control[2]. In decoupling process, the three-phase mathematical model of PMSM will be changed into the two-phase mathematical model using Clarke and Parke transformations[3]. The Clarke transformation converts the balanced three-phase quantities into two-phase stationary reference frame. The Park transformation converts from stationary reference frame into a rotating reference frame.

When PMSM is used as a driving force in an electric vehicle, this out of synchronization can cause problems. When the vehicle is moving on a flat road as shown in Fig. 1.(a), due to the effect of vehicle loads, there can be a magnetic slip, as shown in Fig. 1.(b). Although the direction of the flux is the same, with different speeds ($\omega_e \rangle\rangle \omega_m$), the motor will be asynchronous. Not only on flat roads, the asynchronous condition also occurs in vehicles that are moving on uphill roads, as shown in Fig.1.(c). Because of the effects of gravity, where the vehicle gets as much force in the opposite direction, the vehicle can run backward. This condition is dangerous for the passenger of the vehicle. In Fig.1.(d), a magnetic slip condition is indicated when the vehicle is on an uphill road. Unlike when a vehicle moves on a flat road where the direction of the stator flux is equal to the rotor flux, the magnetic slip condition when the vehicle is running on an uphill has a stator flux direction that is not equal to the rotor flux.



(a) Flat road b) Magnetic slip on the flat road

(c) Uphill road (d) Magnetic slip on the uphill road

Figure 1. The illustration of the vehicle on the road

If the initial position of the rotor (θ_r) differs from the controller's initial position, it can cause problems, especially if the PMSM is used as an electric vehicle, as illustrated in Fig. 1. This condition increases if the motor gets a large load. A large load on the motor can also cause problems. As explained by Harini, B.W. et al[4], the electric vehicle actually moves in the wrong direction when a large load that has reverse torque direction is given to the motor. Different from that paper where the system used a sensorless system, this paper will present the effect of initial position and load on PMSM if the system uses incremental encoder sensor.

The initial position of the rotor is very important in the control of PMSM. Jung, D.H. et al have described an efficient method for identifying the initial position of a permanent magnet synchronous motor (PMSM) with an incremental encoder, even when a brake and/or a constant load torque is being applied[5]. However, in this paper, there is no explanation of the effect of the initial position on the motor current. Lei, Wang et al have proposed a method to identify the rotor position polarity[6]. This paper didn't describe the effect of the initial position on the motor current. All papers didn't research the phenomena as illustrated in Fig.1.

The control system that will be analyzed uses Proportional Integral (PI) as a current controller and

Authorized licensed use limited to: Universitas Indonesia. Downloaded on June 17,2020 at 10:04:47 UTC from IEEE Xplore. Restrictions apply.

incremental encoder as a sensor. The effect of the load and initial position on PMSM control will be analyzed on both road condition, as illustrated in Fig.1.

II. PMSM Model

The Park transformation converts from stationary reference frame into a rotating reference $(d, q, 0)$ frame using (1).

$$\begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} = \begin{bmatrix} \cos\theta_r & \sin\theta_r \\ -\sin\theta_r & \cos\theta_r \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \end{bmatrix} \quad (1)$$

The PMSM mathematical model in the d-q frame [2] is

$$\begin{bmatrix} v_{sd} \\ v_{sq} \end{bmatrix} = \begin{bmatrix} R_s + pL_s & -N\omega_r L_s \\ N\omega_r L_s & R_s + pL_s \end{bmatrix} \begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} + \begin{bmatrix} 0 \\ N\omega_r \psi_F \end{bmatrix} \quad (2)$$

where v_{sd} is the stator voltage in d-axis, v_{sq} is the stator voltage in q axis, i_{sd} is the stator current in d-axis, i_{sq} is the stator current in q-axis. The equation (5) can be stated as

$$\frac{d}{dt} i_{sd} = \frac{V_{sd} - R_s i_{sd} + N\omega_r L_{sq} i_{sq}}{L_{sd}} \quad (3)$$

$$\frac{d}{dt} i_{sq} = \frac{V_{sq} - i_{sd} N\omega_r L_{sd} - R_s i_{sq} - N\omega_r \psi_F}{L_{sq}} \quad (4)$$

The electric torque of PMSM is

$$T_e = \left\{ \psi_F i_{sq} + \left(L_{sd} - L_{sq} \right) i_{sd} i_{sq} \right\} \quad (5)$$

where L_{sd} is the stator inductance in d-axis and L_{sq} is the stator inductance in q-axis.

The mechanical model of PMSM [7] is

$$\frac{d\theta_r}{dt} = N\omega_r \quad (6)$$

where

$$\frac{d\omega_r}{dt} = \frac{T_e - T_L}{J} \quad (7)$$

where θ_r is the position of the rotor, ω_r is the speed, T_L is the load torque and J is the inertia of the motor.

III. PMSM Sensor Control

Block diagram of the PMSM sensor control system is shown in Fig. 2. Each part will be explained below.

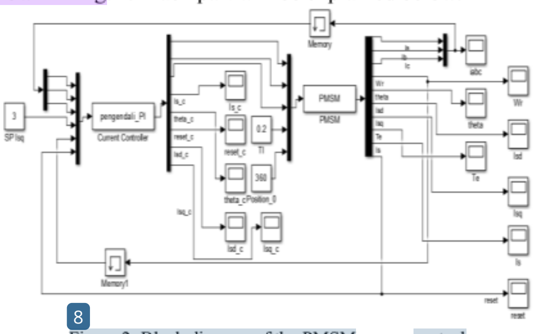


Figure 2. Block diagram of the PMSM sensor control

A. Decoupling

Decoupling part is used to decouple cross-coupling between d and q-axis components (ω and i) which is not linear. This is necessary because the PI controller can only control the linear equations. The decoupling equations [8] are

$$V_{sd} = U_{sd} - N\hat{\omega}_r L_{sq} i_{sq1} \quad (8)$$

$$V_{sq} = U_{sq} + N\hat{\omega}_r L_{sd} i_{sd1} + N\hat{\omega}_r \psi_F \quad (9)$$

where

$$\frac{d}{dt} i_{sd1} = \frac{1}{T_d} i^*_{sd} - \frac{1}{T_d} i_{sd1} \quad (10)$$

$$\frac{d}{dt} i_{sq1} = \frac{1}{T_d} i^*_{sq} - \frac{1}{T_d} i_{sq1} \quad (11)$$

$$\frac{d}{dt} X_{sd} = i^*_{sd} - i_{sd} \quad (12)$$

$$\frac{d}{dt} X_{sq} = i^*_{sq} - i_{sq} \quad (13)$$

where i^*_{sd} is the set point of i_{sd} and i^*_{sq} is the set point of i_{sq}.

B. Current Controller

The phase angle and the modulus of the current in an A.C. machine have to be controlled. It means that the current vector has to be controlled [2], so the torque and flux producing current components are independently controlled. This is done by controlling the stator current in the d-q reference frame using Proportional Integrator (PI). The current controller equations [8] are

$$u_{sd} = K_{pd}\left(i^*_{sd} - i_{sd}\right) + K_{id} \int \left(i^*_{sd} - i_{sd}\right) dt \quad (14)$$

$$u_{sq} = K_{pq}\left(i^*_{sq} - i_{sq}\right) + K_{iq} \int \left(i^*_{sq} - i_{sq}\right) dt \quad (15)$$

where K_{pd}, K_{id}, K_{pq}, and K_{iq} are the current controller gain in the d-q frame. The values of each gain are

$$K_{pd} = \frac{L_{sd}}{T_d} \qquad K_{id} = \frac{R_s}{T_d} \qquad K_{pq} = \frac{L_{sq}}{T_d} \qquad K_{iq} = \frac{R_s}{T_d} \quad (16)$$

IV. Methods

PMSM that we are used has parameters shown in Table I. The sensorless control system of PMSM is simulated using Matlab. The system is analyzed in two conditions. They are

a. The vehicle runs on the flat road. The flat road is represented by a zero load. ($T_L = 0$)
b. The vehicle runs on the uphill. The uphill path is represented with a non-zero (T_L) load, in which case the test is performed for $T_L = 0.16$ N.m.

The tests of both conditions were conducted at different starting positions ($\Delta\theta$), ie 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0, 315^0, and 360^0. $\Delta\theta$ is the difference between θ_r and θ_c. The variables tested are the i_d and i_q values when the initial rotor position is the same and different.

Authorized licensed use limited to: Universitas Indonesia. Downloaded on June 17,2020 at 10:04:47 UTC from IEEE Xplore. Restrictions apply.

TABLE I. PMSM PARAMETERS

Parameters	Quantities	Unit	Description
Td	0.01	second	Time constant of current controller
dt	0.0001	second	Sampling time of controller
N	4		Number of pole pairs
R_s	0.14710296	Ω	Stator resistance
L_{sd}	0.29420592	mH	Stator inductance in d-axis
L_{sq}	0.382467696	mH	Stator inductance in q-axis
Ke	0.055977	Vpeak/rad/s	Electrical constant
psi (ψ_F)	0.0133994	Ke/N	Magnet flux linkage
J	0.01	kgm^2	Motor inertia

The control system uses

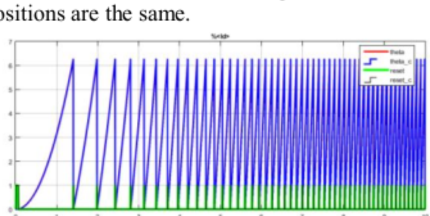
a. An incremental encoder as the speed sensor.
b. The Proportional Integral (PI) controller is used for the current control
c. The constants of the current controller are obtained from the formula in equation 16.
d. The set point of i_{sd}^{*} is 0A.
e. The set point of i_{sq}^{*} is 1.86A.

V. RESULTS AND DISCUSSION

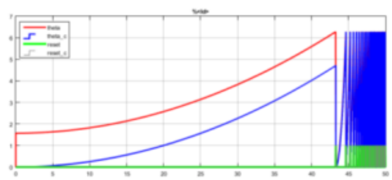
The system is tested on two conditions, i.e. the system is tested on the flat and uphill road. In this test, the initial position of PMSM is set at a certain angle. Speed (ω_r) is measured using an incremental encoder. The controller output position (θ_c) is reset so that the control position is equal to the rotor position (θ_r).

A. Testing on a Flat Road

When the vehicle runs on a flat road, the motor is applied a zero load ($T_L = 0$). Fig. 3.a shows the reset process with an initial position of 0^0. It appears that the position of the rotor and the output position of the controller from the start are the same. Fig. 3.b shows the reset process with an initial position of 90^0. It appears that the start is at the rotor position of 90^0 or 1.57 radians while the controller output position (θ_c) is at position 360^0 (6.28 radians). When at position 0^0, it is reset so that it is at position 0^0. After reset, both positions are the same.



a. $\theta_{r0} = 0^0$

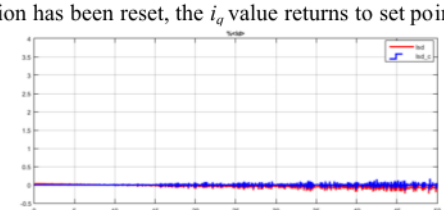


b. $\theta_{r0} = 90^0$

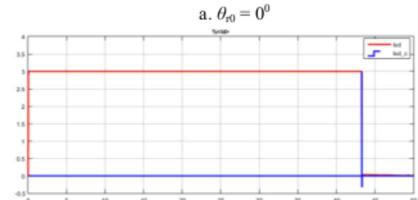
Figure 3. Reset process under load conditions = 0 N.m.

This condition also affects the i_d and i_q values. Fig. 4.a shows the i_d values when the starting position is the same. Fig. 4.b shows the i_d values when the starting position is different. The problem occurs when the initial position of the rotor differs from the controller's output position. It appears that the i_d current overshoots to 3 A for 43 seconds. At the 43[rd] seconds where the controller output position has been reset, the i_d value returns to set point (0 A).

This condition also occurs at the i_q value, as shown in Fig. 5. When the initial position of the rotor differs from the controller's output position, the i_q current drops to 0 A for 43 seconds. At the 43[rd] seconds where the controller output position has been reset, the i_q value returns to set point (3 A).

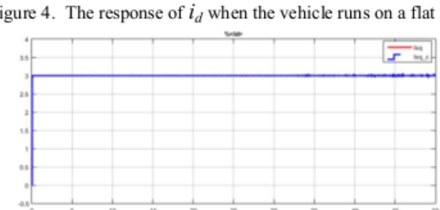


a. $\theta_{r0} = 0^0$

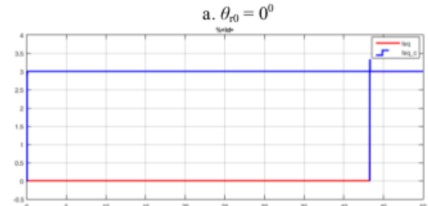


b. $\theta_{r0} = 90^0$

Figure 4. The response of i_d when the vehicle runs on a flat road



a. $\theta_{r0} = 0^0$

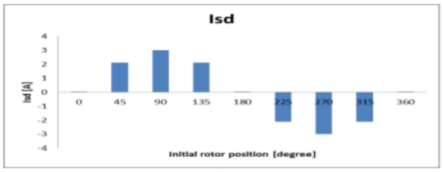


b. $\theta_{r0} = 90^0$

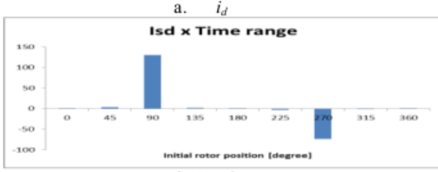
Figure 5. The response of i_q when the vehicle runs on a flat road

Authorized licensed use limited to: Universitas Indonesia. Downloaded on June 17,2020 at 10:04:47 UTC from IEEE Xplore. Restrictions apply.

Fig. 6.a shows the overshoot changes in i_d values to different starting positions. Fig. 6.b shows the changes in the i_d value multiplied by the time. Fig. 7.a shows the overshoot changes in the i_q value to different starting positions, whereas Fig. 7.b shows the change in the i_q value multiplied by the time.

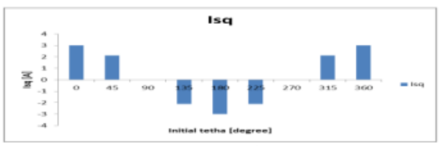


a. i_d

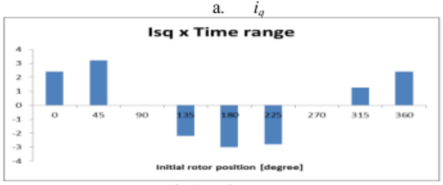


b. i_d x time range

Figure 6. The condition of i_d versus initial position on a flat road conditions.



a. i_q



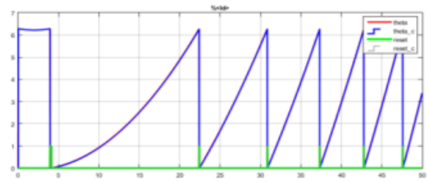
b. i_q x time range

Figure 7. The condition of i_q versus initial position on a flat road conditions.

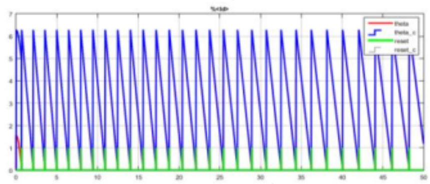
Fig. 6 and 7 show that both the current i_d and i_q at different starting positions have different values. From Fig.6.b and 7.b, it appears that the worst response occurs when the rotor's initial position is 90^0 and 270^0. This shows that initial position synchronization on PMSM is very important.

B. Testing on an Uphill Road

Testing on an uphill road is done with is applied a load T_L = 0.16 N.m. Fig. 8.a shows the reset process with an initial position of 0^0. It appears that the position of the rotor and the output position of the controller from the start are the same. Fig. 8.b shows the reset process with an initial position of 90^0. It appears that the start is at the rotor position of 90^0 or 1.57 radians while the controller output position (θ_c) is at position 360^0 (6.28 radians). When at position 0^0, it is reset so that it is at position 0^0. After reset, both positions are the same.



a. $\theta_{r0} = 0^0$

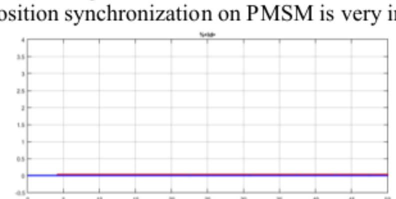


b. $\theta_{r0} = 90^0$

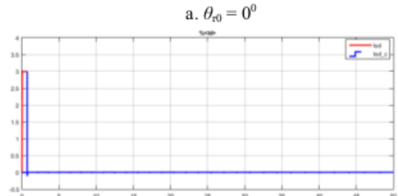
Figure 8. Reset process under load conditions = 0.16 N.m.

As happens when the motor is moving on a flat road, this condition also affects the i_d and i_q values. Fig. 9.a shows the i_d values when the starting position is the same. Fig. 9.b shows the i_d values when the starting position is different. The problem also occurs when the initial position of the rotor differs from the controller's output position. It appears that the i_d current overshoots to 3 A. After a reset, the i_d value returns to set point (0 A). Fig.10 shows the i_q value when the motor runs on an uphill road. When the initial position of the rotor differs from the controller's output position, the i_q current drops to 0 A. After a reset, the i_q value returns to set point (3 A). Fig. 9 and 10 show that initial position synchronization on PMSM is very important.

Fig. 11.a shows the overshoot changes in i_d values to different starting positions. Fig. 11.b shows the changes in the i_d value multiplied by the time. Fig. 12.a shows the overshoot changes in the i_q value to different starting positions, whereas Fig. 12.b shows the change in the i_q value multiplied by the time. It appears that both the current i_d and i_q at different starting positions have different values. Fig.11.b and 12.b show that the worst response occurs when the rotor's initial position is 90^0 and 270^0. This shows that initial position synchronization on PMSM is very important.



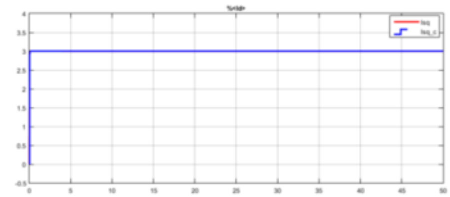
a. $\theta_{r0} = 0^0$



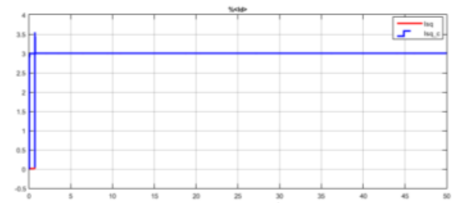
b. $\theta_{r0} = 90^0$

Figure 9. The response of i_d when the vehicle runs on an uphill road

Authorized licensed use limited to: Universitas Indonesia. Downloaded on June 17,2020 at 10:04:47 UTC from IEEE Xplore. Restrictions apply.

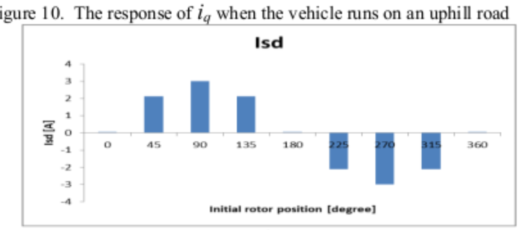


$\theta_{r0} = 0^0$

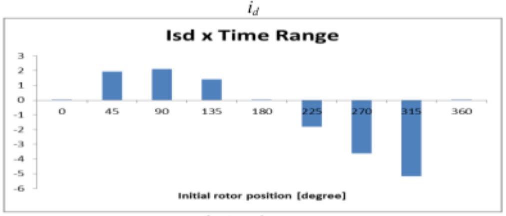


$\theta_{r0} = 90^0$

Figure 10. The response of i_q when the vehicle runs on an uphill road

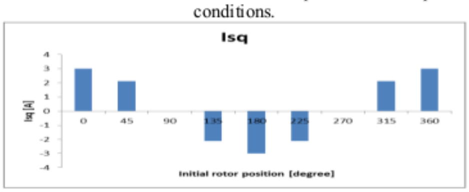


i_d

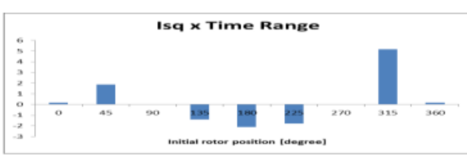


b. i_d x time range

Figure 11. The condition of i_d versus initial position on an uphill road conditions.



a. i_q



b. i_q x time range

Figure 12. The condition of i_d versus initial position on an uphill road

VI. Conclusion

From the above analysis, it appears that PMSM motors used as vehicles still have problems, both when runs on a flat road and an uphill road. This issue is very important to be solved. In addition to detecting the initial position of the rotor, so that the current i_d and i_q correspond to the set point value, the rotor is rotated first to get the zero crossing. At zero crossing, the controller output position is reset to equal the rotor position. At this point, the i_d and i_q value return to the set point value.

Acknowledgment

This research is funded by Universitas Indonesia research grant of the *Publikasi International Terindeks untuk Tugas Akhir Mahasiswa* UI (PITTA) 2018.

References

[1] E. Edge. (2000). *Synchronous Motor Starting Review*.

[2] P. Vas, *Sensorless vector and direct torque control*: Oxford University Press, USA, 1998.

[3] F. Semiconductor, "Sensorless PMSM vector control with a sliding mode observer for compressors using MC56F8013," *Document Number*, 2008.

[4] B. W. Harini, A. Subiantoro, and F. Yusivar, "Study of speed sensorless permanent magnet synchronous motor (PMSM) control problem due to braking during steady state condition," in *Quality in Research (QiR): International Symposium on Electrical and Computer Engineering, 2017 15th International Conference on*, 2017, pp. 184-189.

[5] D.-H. Jung and I.-J. Ha, "An efficient method for identifying the initial position of a PMSM with an incremental encoder," *IEEE Transactions on Industrial electronics*, vol. 45, pp. 682-685, 1998.

[6] W. Lei, "Study on initial rotor position identification of permanent magnet synchronous motor based on high frequency signal injection," in *Informatics in Control, Automation and Robotics (CAR), 2010 2nd International Asia Conference on*, 2010, pp. 397-401.

[7] A. S. Mohamed, M. S. Zaky, A. Z. El Din, and H. A. Yasin, "Comparative study of sensorless control methods of PMSM drives," *Innovative Systems Design and Engineering,* vol. 2, pp. 44-67, 2011.

[8] A. S. Mohamed, M. S. Zaky, A. Z. El Din, and H. A. Yasin, "Comparative study of sensorless control methods of PMSM drives," *Innovative Systems Design and Engineering,* vol. 2, pp. 2222-1727, 2011.

Authorized licensed use limited to: Universitas Indonesia. Downloaded on June 17,2020 at 10:04:47 UTC from IEEE Xplore. Restrictions apply.

Effect of Initial Rotor Position on Rotor Flux Oriented Speed Permanent Magnet Synchronous Motor Control using Incremental Encoder

ORIGINALITY REPORT

24%	16%	22%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Zhao Wang, Quande Liu, Qi Dou. "Contrastive Cross-site Learning with Redesigned Net for COVID-19 CT Classification", IEEE Journal of Biomedical and Health Informatics, 2020 Publication	3%
2	Jaroslaw Guzinski, Marcin Morawiec, Zbigniew Krzeminski, Krzysztof Luksza, Patryk Strankowski, Abdellah Kouzou. "Sensorless Low Speed PMSM Motor Control with Cogging Torque Compensation", 2019 2nd International Conference on Smart Grid and Renewable Energy (SGRE), 2019 Publication	2%
3	Yihui Cao, Junzheng Wang, Wei Shen. "A No-disturbance Startup Scheme for PMSM Speed Loop with Auto-tuned Current Loop", 2019 Chinese Control Conference (CCC), 2019 Publication	1%
4	ijsrset.com Internet Source	1%

5	Tuan Dat Hoang, Amritam Das, Sjirk Koekebakker, Siep Weiland. "Sensorless Field-Oriented Estimation of Hybrid Stepper Motors in High-Performance Paper Handling", 2019 IEEE Conference on Control Technology and Applications (CCTA), 2019 Publication	1%
6	ies.ieee-ies.org Internet Source	1%
7	M V Tejeswini, I Jacob Raglend. "Modelling and sizing techniques to mitigate the impacts of wind fluctuations on power networks: A Review", International Journal of Ambient Energy, 2020 Publication	1%
8	hdl.handle.net Internet Source	1%
9	sinta3.ristekdikti.go.id Internet Source	1%
10	"Table of contents", 2018 2nd International Conference on Smart Grid and Smart Cities (ICSGSC), 2018 Publication	1%
11	Xie Yue, D.M. Vilathgamuwa, King-Jet Tseng. "Observer-based robust adaptive control of pmsm with initial rotor position uncertainty",	1%

IEEE Transactions on Industry Applications, 2003

Publication

12	Aries Subiantoro, Fauzan Muzakir, Feri Yusivar. "Adaptive Cruise Control Based on Multistage Predictive Control Approach", 2018 4th International Conference on Nano Electronics Research and Education (ICNERE), 2018 Publication	1 %
13	Suwandi Dwi Sahputro, Fahmi Fadilah, Nanda Avianto Wicaksono, Feri Yusivar. "Design and implementation of adaptive PID controller for speed control of DC motor", 2017 15th International Conference on Quality in Research (QiR) : International Symposium on Electrical and Computer Engineering, 2017 Publication	1 %
14	Agamloh, Emmanuel B., Iqbal Husain, and Ali Safayet. "Investigation of the electrical system design concept and grid connection of ocean energy devices to an offshore compressed energy storage system", 2012 IEEE Energy Conversion Congress and Exposition (ECCE), 2012. Publication	1 %
15	Nanda Avianto Wicaksono, Bernadeta Wuri Harini, Feri Yusivar. "Sensorless PMSM	1 %

Control using Fifth Order EKF in Electric Vehicle Application", 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), 2018
Publication

16	X. Yue, D.M. Vilathgamuwa, K.-J. Tseng. "An Observer-Based Robust Adaptive Controller for Permanent Magnet Synchronous Motor Drive With Initial Rotor Angle Uncertainty", IEEE Transactions on Energy Conversion, 2005 Publication	1 %
17	ethesis.nitrkl.ac.in Internet Source	1 %
18	www.coursehero.com Internet Source	1 %
19	www.hindawi.com Internet Source	1 %
20	David Uzel, Zdenek Peroutka. "Control and design considerations for wheel mounted drive of tram: Interesting features offered by IPMSM technology", Proceedings of 14th International Power Electronics and Motion Control Conference EPE-PEMC 2010, 2010 Publication	<1 %
21	Ashley Levin, Alan Clark, Charles Landy. "A Re-Engineered Modelling and Simulation	<1 %

Environment for Teaching Generalised Machines Theory", International Journal of Electrical Engineering Education, 2012
Publication

22	publications.waset.org Internet Source	<1%
23	Dahlia Canny, Feri Yusivar. "Maximum Power Point Tracking (MPPT) Algorithm Simulation Based on Fuzzy Logic Controller on Solar Cell with Boost Converter", 2018 2nd International Conference on Smart Grid and Smart Cities (ICSGSC), 2018 Publication	<1%
24	Li, Bao, and Guang Xu Zhou. "Research on Automatic Detection Method about Rotor Initial Position of Permanent Magnet Synchronous Motor", Applied Mechanics and Materials, 2013. Publication	<1%
25	Poonam Jayal, Samiksha Rawat, G. Bhuvaneswari. "Simplified Sensor Based Vector Control of Permanent Magnet Synchronous Motor Drive", 2020 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy (PESGRE2020), 2020 Publication	<1%

26	Zhengqiang Song, Huiling Yang. "Hardware detection and parameter tuning method for speed control system of PMSM", IOP Conference Series: Materials Science and Engineering, 2018 Publication	<1 %
27	digitalcommons.lsu.edu Internet Source	<1 %
28	www.ukessays.com Internet Source	<1 %
29	Daxing Chen, Peide Sun, Wei Jiang. "Initial rotor position detection of PMSM without detecting the UVW's position", 2011 International Conference on Electrical and Control Engineering, 2011 Publication	<1 %
30	Jianhua Ding, Tao Zhang, Ran Tao, Anna Wang. "Research on PMSM Vector Control System Based on Fuzzy PI Parameter Self-Tuning", 2020 10th International Conference on Power and Energy Systems (ICPES), 2020 Publication	<1 %
31	N. Capitanie, N. Xiao. "Some terms of nutation derived from the BIH data", Geophysical Journal International, 1982 Publication	<1 %

documents.mx

32	Internet Source	<1 %
33	epdf.pub Internet Source	<1 %
34	jeasonline.org Internet Source	<1 %
35	journal.uad.ac.id Internet Source	<1 %
36	www.mdpi.com Internet Source	<1 %
37	Qixin Zhu, Lei Xiong, Hongli Liu, Yonghong Zhu, Guoping Zhang. "A New Open Loop Approach for Identifying the Initial Rotor Position of a Permanent Magnet Synchronous Motor", Journal of Control Science and Engineering, 2017 Publication	<1 %
38	Yulong Huang, Jingjun Wang, Wenchao Zhang, Mohmmad Al-Dweikat, Dawei Li, Tao Yang, Shengnan Shao. "A Motor-Drive-Based Operating Mechanism for High-Voltage Circuit Breaker", IEEE Transactions on Power Delivery, 2013 Publication	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		