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Analysis of the use of a 4 kW BLDC motor to drive a 1GT electric passenger boat

Anggara Fuad Al Amin, Supari, Satria Pinandita*

* Electrical Engineering, Faculty of Engineering, Semarang University, Indonesia, 50196

* satria_p@usm.ac.id

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ABSTRACT

Passenger boats are a means of transportation that is used to transport passengers to a destination. One of them is a boat for passengers to visit the religious tour of Sheikh Mudzakir's grave. The religious tourism location of Sheikh Mudzakir's grave is located about 2 km north of Blekok Island. However, this passenger boat still relies on fuel oil as fuel to drive the passenger boat's combustion engine. Research on electric boats was carried out by several students at Semarang University. This electric boat uses solar panel technology installed on it to harvest solar energy and convert it into electricity which is stored in batteries to move the boat. This electric boat uses a 3 Phase 1 HP 4 Pole electric motor that uses solar charge control and an inverter as a converter from 12 V DC to 380 V AC. Using a 3 Phase Electric Motor requires a large amount of electricity, because it requires electricity that must be converted to voltage. high, will result in high loss, so that the efficiency of battery use is relatively wasteful. The aim of this research is to carry out tests using a 4 kW 72 Volt BLDC Motor as an alternative solution to replace previous research which used a 3 Phase 1 HP Motor on an electric passenger boat. The results show that the motor rotation of a 4 kW 72 Volt BLDC motor tends to be greater than using a 3 Phase 1 HP electric motor and a 9 HP fuel engine, where previous research showed that the speed of an electric boat can only reach a maximum speed of 4.4 Knots at high mode gas level. , while using a 4 kW 72 Volt BLDC motor it can reach a speed of 8 Knots, which is a huge improvement. Very suitable for using a 4 kW 72 Volt BLDC motor on a 1GT electric boat.

Keywords: Passenger boat; BLDC; electric boat

1. INTRODUCTION

Passenger boats are a means of transportation used to transport passengers to a destination. Passenger boats transport in waters such as rivers, coastlines and so on [1]. One of them is a boat for passengers to visit the religious tour of Sheikh Mudzakir's grave. The religious tourism location of Sheikh Mudzakir's grave is located about 2 km north of Blekok Island. Blekok Island is land that was once a village for residents, but as a result of abrasion and tidal waves, now this land is increasingly eroded and separated from Bedono Village, Sayung Demak District. So, to get to the religious tourism site of Sheikh Mudzakir's grave, you can use motorbike taxi boat transportation. However, this passenger boat still relies on fuel oil (BBM) as fuel to drive the passenger boat's combustion engine [2]. This is very unprofitable and inefficient, because fuel prices are increasing every year [3].

The impact of the increase in fuel oil is very detrimental for boat motorcycle taxi owners [4][5], the high purchase of fuel oil will have an impact on boat owners spending money to buy this fuel [6]. The decline in boat taxi income due to the decline in visitors to uncertain religious tourist attractions has resulted in reduced income for families. This has resulted in a reduction in boat taxi drivers as they look for other jobs to meet household needs [7][8].

Research on electric boats was carried out by several students at Semarang University. This electric boat uses solar panel technology installed on it to harvest solar energy and convert it into

electricity which is stored in batteries to move the boat [9]. This electric boat uses a 3 phase 1 HP 4 Pole electric motor drive which uses solar charge control and an inverter as a converter from 12 V DC voltage to 380 V AC. Using a 3 phase electric motor requires a large amount of electricity, because it requires electricity that must be converted to voltage. high, will result in high lossis [10][11], so the efficiency of battery use is relatively wasteful. In previous research, the use of this motor was not efficient and still had the boat's propulsion at a speed of 4-6 knots [12].

This research wants to carry out tests using a 4 kW 72 Volt BLDC motor as an alternative solution to replace previous research which used a 3 phase 1 HP motor on a 1 GT electric passenger boat. The aim of this research is to analyze the use of a 4 kW 72 Volt BLDC motor to drive a 1 GT electric passenger boat. This drive system is an important component that plays a role in moving the propeller to run the boat. It is hoped that by using a 4 kW 72 Volt BLDC motor, the electrical energy consumption required will not be wasteful and more efficient because there is no need to convert high voltage.

2. METHOD

The research location was carried out in Bedono Village, Sayung District, Demak Regency for 3 months starting from October to December 2023. The passenger boat testing location started from the boat berth at coordinates: -6.926569, 110.482513 to the religious tourist attraction of Sheikh Abdullah Mudzakir's grave at coordinates : -6.914607, 110.481608 approximately 1.5 km away as shown in Figure 1.

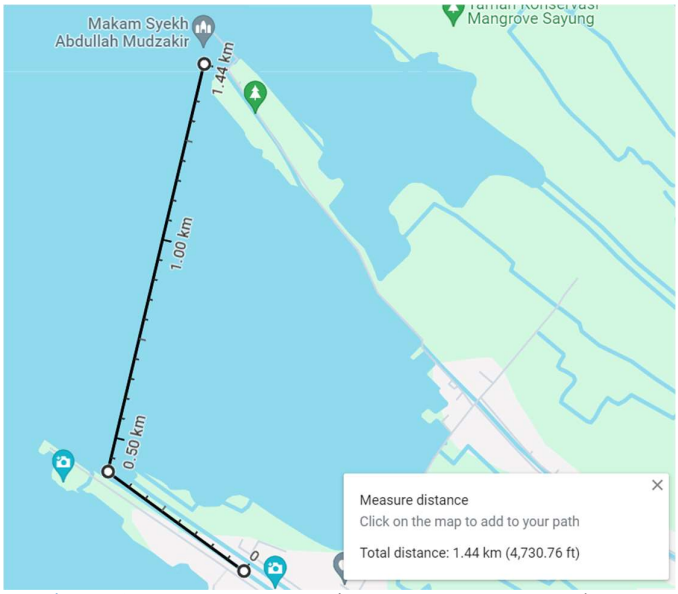

Figure 1. BLDC motor testing map on passenger boats

In this study, the research subject was the propulsion system on the boat using a 4 kW 72 Volt BLDC motor with a 72 Volt 55 Ah battery system. The equipment needed for this research includes: ampere pliers, tachometer, wattmeter, Votol driver software. Materials needed in this research include: 4 kW 72 Volt BLDC motor, 72 Volt 55 Ah battery, Votol EM-150 Driver, 600 Wp solar panel, 90 Volt MPPT MV.

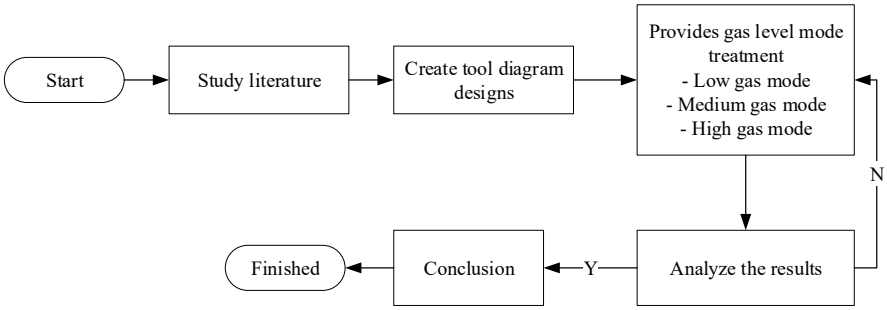

Figure 2. Research flow scheme

Figure 2 the flow scheme in this research is aimed at drawing the first 2 stages where a literature search will be carried out regarding the use of propulsion systems on passenger boats to replace more environmentally friendly oil-fueled engines with replacement types of electric motors. Previously researched electric motors used 3 phase 1 HP electric motors [12], however, energy consumption is still large and wasteful [11] So in this research we want to carry out an analysis of the use of a 4 kW 72 Volt BLDC motor in a passenger boat propulsion system. The 4 kW 72 Volt BLDC motor is given gas level treatment, 1. low gas mode, 2. medium gas mode, 3. high gas mode then the data results are processed to determine the efficiency of the motor. Then create a design block diagram shown in Figure 3.

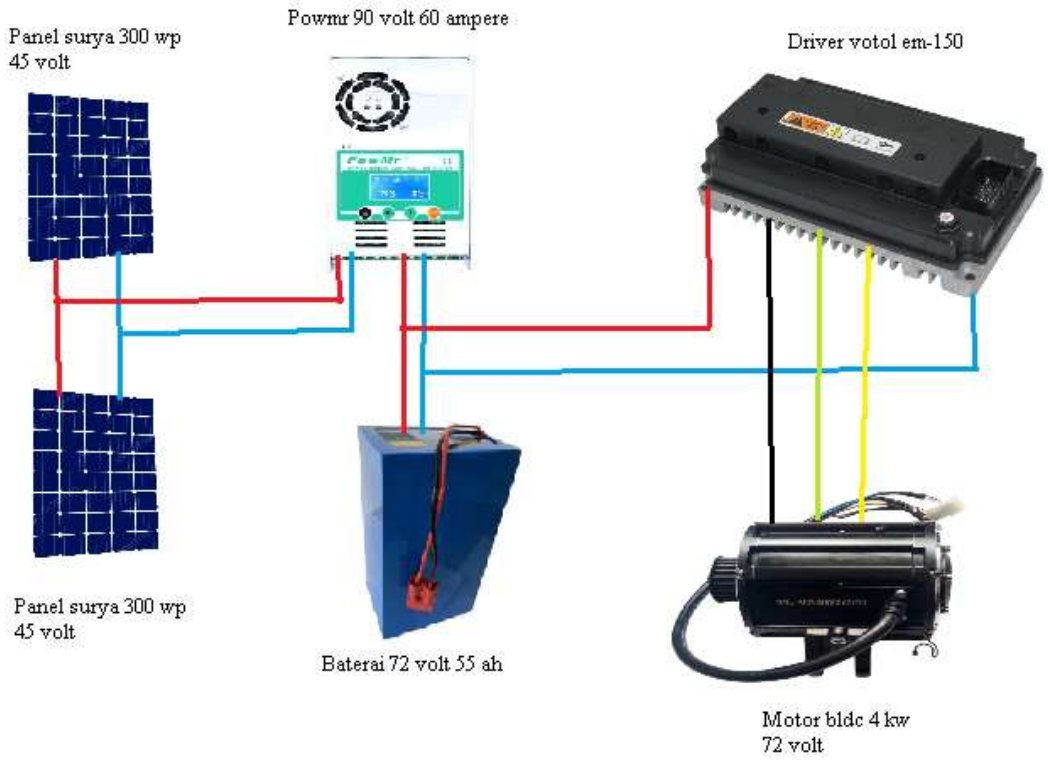

Figure 3. Schematic of an electric boat installation circuit.

In this research, the electric boat installation circuit scheme is shown in Figure 3. Testing is required on a 4 kW 72 Volt BLDC motor that has been installed on a 1 GT passenger boat by providing gas level mode treatment as a comparison of the movement speed of the BLDC motor on the passenger boat. The boat has components and circuits that have been arranged in such a way starting from 2 solar panels with specifications per panel of 300 Wp with a voltage output of 45 volts installed in series so that the voltage reaches 90 Volts on the roof of the boat.

Then, the installation is connected to the MPPT 90 Volt PV input to convert the 90 Volt solar panel voltage to 72 Volt which is used to recharge the 72 Volt 55 Ah battery by utilizing the battery output at the MPPT. Next, with the voltage from the battery that is already charged or in the best condition, connect it to the Votol Em-150 driver as a converter from 72 volt DC voltage to a stable 3 phase voltage to supply the 4 kW 72 Volt BLDC motor power source.

The motor voltage must be stable so that the motor rotation is normal and maximum [11] because if the voltage is weak or the phases are very different it will cause damage to the BLDC motor [13][14]. Another function of the Votol is as a motor rotation speed regulator which is assisted by rotation of the throttle connected to the Votol EM-150 to set low, medium and high gas modes. With this circuit, the 4 kW 72 Volt BLDC motor can be used as an environmentally friendly boat driver.

The results of the measurement data will be taken using the default software from the Votol EM-150 and manual measurements on the 4 kW 72 Volt BLDC motor and the Votol EM-150, namely rotation on the motor using a tachometer and current measurements using ampere pliers and voltage

measurements using a multimeter on the Votol . Measurements were carried out repeatedly 5 times on each sample.

3. RESULTS AND DISCUSSION

3.1 Measurement of voltage, current and rotation of a 4 kW BLDC motor using Votol driver software

In this research, voltage, current and motor rotation values were tested on a 4 kW 72 Volt BLDC motor using Votol driver software with various treatments in gas level mode to find out how much electrical energy consumption a 4 kW BLDC motor can work. Table 1 results of measurements in low gas mode with 4 kW 72 Volt BLDC motor votol driver software.

Table 1. Mode gas low software driver votol EM-150

Repetition	Voltage	RPM	Current	Knot
1	79	899	3,8	4
2	78,9	931	3,8	4
3	78,9	909	3,7	4
4	78,9	928	3,9	4
5	78,8	944	3,9	4
Average	**78,9**	**922,2**	**3,82**	**4**

Table 1 shows that in low gas level mode the 4 kW 72 Volt BLDC motor produces a motor rotation of 922.2 Rpm requiring 301.39-Watt power resulting in a boat thrust of 4 Knots. Table 2 results of medium gas mode measurements with 4 kW 72 Volt BLDC motor votol driver software.

Table 2. Medium gas mode software driver votol EM-150

Repetition	Voltage	RPM	Current	Knot
1	78,4	1170	6,3	6
2	78,4	1220	7	6
3	78,3	1270	7,1	6
4	78,2	1282	7,8	6
5	78,1	1287	7,7	6
Average	**78,28**	**1245,8**	**7,18**	**6**

Table 2 shows that in medium gas level mode the 4 kW 72 Volt BLDC motor produces motor rotation of 1245.8 Rpm requiring 562-Watt power resulting in a boat thrust of 6 Knots. Table 3 results of high gas mode measurements with 4 kW 72 Volt BLDC motor votol driver software.

Table 3. Mode gas high software driver votol EM-150

Repetition	Voltage	RPM	Current	Knot
1	76,4	1884	20,6	8
2	75,6	2056	28,7	8
3	76,2	1948	23,3	8
4	75,9	1997	25,6	8
5	75,6	2061	27,7	8
Average	**75,94**	**1989,2**	**25,18**	**8**

Table 3 shows that in high gas level mode the 4 kW 72 Volt BLDC motor produces a motor rotation of 1989.2 Rpm requiring 1912 Watts of power resulting in a boat thrust of 8 Knots.

3.2 Providing treatment in gas level mode on a 4 kW 72 Volt BLDC motor and taking measurements using a measuring instrument.

In this research, voltage, current and motor rotation values were tested on a 4 kW 72 Volt BLDC motor using manual measurements with various treatments in gas level mode to find out how much electrical energy consumption a 4 kW 72 Volt BLDC motor can work. The results of the

measurements in Table 4 are the results of measuring the low gas mode manually for a 4 kW 72 Volt BLDC motor.

Table 4. Low gas mode manual measurement of driver EM-150 and BLDC motor 4 kW 72 Volt

Connected	Voltage Measurement			RPM	Current	Knot
	UV	VW	UW			
1	26,1	27,8	28,2	1344	13,2	4
2	19,6	20,5	20,8	1215	9,2	4
3	18,7	19,1	19,7	1139	8,4	4
4	21	23,8	24,9	1184	11	4
5	25,6	26	28,1	1047	11,8	4
Rata-rata	**22,2**	**23,44**	**24,34**	**1186**	**10,72**	**4**

The results of Table 4 show that in gas level low mode, measuring the voltage using a multimeter between UV phases produces a voltage of 22.2 Volts, between VW phases produces a voltage of 23.44 Volts, and between Phase UW produces a voltage of 24.34 Volts. The voltage measurement at each phase of the BLDC motor is stable so that it does not cause the motor to spin lamely [13][14] regulated by the Votol EM-150. Measuring motor rotation produces 1186 Rpm, measuring motor power consumption produces 301.39 Watts, and passenger boats can be driven in the 4 Knot sub-district.

Based on research, the speed of a 1 GT boat motor using a fuel engine at low gas level produces a motor rotation of 1800 Rpm with a boat speed capability of 4 Knots. Meanwhile, when compared with the use of a 3 phase 1 HP motor at low level gas it produces a motor rotation of 900 Rpm, and requires an energy consumption of 300 Watts with a boat speed of 0.6 Knots [15][16]. The use of a 4 kW 72 Volt BLDC motor turns out to have a lower motor speed compared to using a fuel engine, but with low motor speed it can reach a boat speed of 4 knots, the same as a fuel engine. However, when compared with a 3 Phase 1 HP electric motor, the results are relatively far apart, it is still more efficient to use a 4 kW BLDC motor. The results of the measurements in Table 5 are the results of manual medium gas mode measurements of a 4 kW BLDC motor.

Table 5. Medium gas mode manual measurement Driver Votol EM-150 and BLDC Motor 4 kW 72 Volt

Connected	Voltage Measurement			RPM	Current	Knot
	UV	VW	UW			
1	41,2	41,9	43,4	2681	55,8	6
2	44,6	42,4	43	3063	51,8	6
3	44,9	45,2	45,3	3425	62,1	6
4	44,7	45,7	46	3562	63	6
5	43,7	43	43,8	3864	50,7	6
Rata-rata	**43,82**	**43,64**	**44,3**	**3319**	**56,68**	**6**

Table 5 shows that in gas level medium mode, measuring the voltage using a multimeter between UV phases produces a voltage of 43.82 Volts, between VW phases produces a voltage of 43.64 Volts, and between UW phases produces a voltage of 44.3 Volts. The voltage measurement at each phase of the BLDC motor is stable so that it does not cause the motor to spin lamely [13] [14] regulated by the Votol EM-150. Measuring the motor rotation tachometer produces 3319 Rpm, measuring motor power consumption produces 562 Watts which results in a boat speed of 6 Knots.

Based on research on the speed of a 1 GT boat motor using a fuel engine at medium gas level, it produces a motor rotation of 2294 Rpm with a boat speed capability of 4.4 Knots. Meanwhile, when compared with the use of a 3 phase 1 HP motor on medium level gas, it produces a motor rotation of 1146.7 Rpm, and requires energy consumption of 335 Watts with a boat speed of 3.6 Knots [15][16].

The use of a 4 kW BLDC motor turns out to have higher motor rotation results compared to the use of a fuel engine and a 3 Phase 1 HP electric motor so that the results are relatively far apart and it

is still more efficient to use a 4 kW BLDC motor. Table 6 results of manual high gas mode measurements of a 4 kW BLDC motor.

Table 6. High gas mode manual measurement of EM-150 motor driver and BLDC motor 4 kW 72 Volt

Connected	Voltage Measurement			RPM	Current	Knot
	UV	VW	UW			
1	63,2	63,9	63,4	5681	92,8	8
2	63,6	63,4	63	5063	84,8	8
3	65,9	65,2	65,3	5425	90,1	8
4	64,7	64,7	66	6562	95,3	8
5	66,7	66	63,8	6864	97,2	8
Average	**64,82**	**64,64**	**64,3**	**5719,38**	**85,48**	**8**

Table 6 shows that in high gas level mode, measuring the voltage using a multimeter between UV phases produces a voltage of 64.82 Volts, between VW phases produces a voltage of 64.64 Volts, and between UW phases produces a voltage of 64.3 Volts. The voltage measurement on each phase of the BLDC motor is stable so that it does not cause the motor to spin lamely [13][14] regulated by the Votol EM-150. Measuring the motor rotation tachometer produces 5719.38 Rpm, measuring motor power consumption produces 1,912 Watts, which results in a boat speed of 8 Knots.

Based on research on the speed of a 1GT boat motor using a fuel engine at medium gas level, it produces a motor rotation of 2688.6 Rpm with a boat speed capability of 4.4 Knots. Meanwhile, when compared with the use of a 3 phase 1HP motor on medium level gas, it produces a motor rotation of 1195 Rpm, and requires energy consumption of 500 Watts with a boat speed of 4 Knots [15] [16].

The use of a 4 kW 72 Volt BLDC motor turns out to have a higher motor rotation result compared to the use of a fuel engine and a 3 phase 1HP electric motor so the results are relatively far apart, it is still more efficient to use a 4 kW 72 Volt BLDC motor.

4. CONCLUSION

Analysis of the use of a 4 kW BLDC motor as a 1GT electric passenger boat driver can be an alternative to replace fuel engines and replace electric motor engines on 1GT passenger boats. The results show that the motor rotation of a 4 kW 72 Volt BLDC motor tends to be greater than using a 3 Phase 1 HP electric motor and a 9 HP fuel engine, where previous research showed that the speed of an electric boat can only reach a maximum speed of 4.4 Knots at high mode gas level. While using a 4 kW 72 Volt BLDC motor it can reach a speed of 8 Knots, which is a very big improvement. Very suitable for use with a 4 kW 72-Volt BLDC motor on a 1GT electric boat.

REFERENCE

[1] M. Maslina dan Fauzan, “Analisa Biaya Operasional Kapal Kotok Terhadap Keselamatan Transportasi Air Pada Pelabuhan Penyeberangan Balikpapan- Penajam,” *Transukma*, vol. 02, no. 01, pp. 84–95, 2016.

[2] E. Tindige, V. E. N. Manoppo, C. R. Dien, and F. Jeannette, “Pembentukan Dan Pengembangan Modalpada Usaha Transportasi Laut Di Kelurahan Papusungan Kecamatan Lembeh Selatan Kota Bitung,” *AKULTURASI J. Ilm. agrobisnis Perikan.*, vol. 11, no. 1, pp. 62–71, 2023.

[3] A. Purwanto, B. Santoso, J. Tandurusa, K. Pos, B. T. G. Bitung, and S. Utara, “Analisis Pengunaan Motor Listrik Sebagai Penggerak Pada Kapal Nelayan 3 GT,” vol. 13, no. 1, pp. 12–15, 2016.

[4] D. H. Priatno and S. -, “Konsep Kapal Pengumpan Reguler untuk Mendukung Angkutan Laut Perintis di Wilayah Pulau-Pulau Terpencil,” *Wave J. Ilm. Teknol. Marit.*, vol. 4, no. 1, pp. 12–20, 2019, doi: 10.29122/jurnalwave.v4i1.3539.

[5] A. Salim, “Pemanfaatan Pelabuhan untuk Meningkatkan Perekonomian Masyarakat Nelayan,” *J. Wacana Equiliberium*, vol. 06, no. 02, pp. 1–14, 2018.

[6] N. Suryawan, “Alih Fungsi Pesisir Pascareklamsi dan Implikasinya terhadap Marginalisasi

Nelayan di Pulau Serangan, Denpasar," *J. Kaji. Bali (Journal Bali Stud.*, vol. 5, no. 1, pp. 57–80, 2015.

[7] R. Julio and O. S. Abdoellah, "Strategi Adaptasi Ekonomi Petani Penggarap terhadap Dampak Pembangunan Jalan Tol," *Umbara Indones. J. Anthropol.*, vol. 7, no. 2, pp. 73–88, 2022.

[8] A. Ansaar, "Peran Istri Nelayan Dalam Menunjang Ekonomi Keluarga Di Kelurahan Bonto Lebang Kabupaten Bantaeng," *Walasuji J. Sej. dan Budaya*, vol. 9, no. 1, pp. 23–36, 2018, doi: 10.36869/wjsb.v9i1.19.

[9] A. B. Pulungan, J. Sardi, H. Hamdani, and H. Hastuti, "Pemasangan Sistem Hybrid Sebagai Penggerak Pompa Air," *JTEV (Jurnal Tek. Elektro dan Vokasional)*, vol. 5, no. 2, p. 35, 2019, doi: 10.24036/jtev.v5i2.106559.

[10] W. Cao, B. C. Mecrow, G. J. Atkinson, J. W. Bennett, and D. J. Atkinson, "Overview of electric motor technologies used for more electric aircraft (MEA)," *IEEE Trans. Ind. Electron.*, vol. 59, no. 9, pp. 3523–3531, 2012, doi: 10.1109/TIE.2011.2165453.

[11] X. Zhou, J. Sun, H. Li, and X. Song, "High performance three-phase PMSM open-phase fault-tolerant method based on reference frame transformation," *IEEE Trans. Ind. Electron.*, vol. 66, no. 10, pp. 7571–7580, 2019, doi: 10.1109/TIE.2018.2877197.

[12] S. Susanto *et al.*, "Pengadaan dan Pemasangan Panel Surya sebagai Sumber Energi Listrik Alternatif untuk Alat Otomatis Pencuci Tangan di Pasar Mitra Raya Kota Batam," *J. Pengabdi. Kpd. Masy. Politek. Negeri Batam*, vol. 3, no. 1, pp. 77–84, 2021, doi: 10.30871/abdimaspolibatam.v3i1.2656.

[13] H. Li, W. Li, and H. Ren, "Fault-Tolerant Inverter for High-Speed Low-Inductance BLDC Drives in Aerospace Applications," *IEEE Trans. Power Electron.*, vol. 32, no. 3, pp. 2452–2463, 2017, doi: 10.1109/TPEL.2016.2569611.

[14] I. Ramirez Ruiz, "High Performance Electromechanical Actuator for Active Rear Axle Kinematics of a Sports Car," *SAE Int. J. Passeng. Cars - Electron. Electr. Syst.*, vol. 5, no. 2, pp. 528–540, 2012, doi: 10.4271/2012-01-0974.

[15] C. S. A. Nandar, A. A. Suryandi, D. R. Mandasari, K. Yulianto, and S. Sumardi, "Rancang Bangun Motor Listrik Submersible pada Aplikasi Bow Thruster Kapal," *J. Nas. Tek. Elektro dan Teknol. Inf.*, vol. 6, no. 4, pp. 4–10, 2017, doi: 10.22146/jnteti.v6i4.358.

[16] A. B. Pulungan, A. Asnil, R. Hidayat, J. Sardi, and S. Islami, "Pemanfaatan Motor Listrik Bertenaga Energi Matahari Sebagai Penarik Jaring Pada Kapal Nelayan," *J. Pendidik. Teknol. Kejuru.*, vol. 2, no. 3, pp. 85–89, 2019, doi: 10.24036/jptk.v2i3.5723.