

Accuracy evaluation of position and speed control of Servo motor using PLC

Revidadina Dwi Junita¹, Muldi Yuhendri¹

¹Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

Article Info

Article history:

Received July 29, 2025

Revised August 30, 2025

Accepted October 25, 2025

Keywords:

Accuracy

PLC

Servo motor

Internet of Things

WinCC RT Advanced

ABSTRACT

The focus of this study is on the accuracy of the SIMOTICS S-1FL6 servo motor control, which is operated using a Siemens S7-1200 PLC and a Sinamics V90 VSD, with the help of a Human Machine Interface (HMI). This study quantitatively examines the motor speed in achieving the desired position (0°-360° unidirectional and clockwise) at 10 and 100 RPM, as well as the rotation accuracy at 10 to 100 RPM. The position accuracy evaluation results indicate that while the system provides good pressure at 10 RPM, the accuracy there is significant at 100 RPM, especially during complex operations. In addition, the overall accuracy of the rotation speed generally indicates the system's ability to achieve the RPM goal, even if there are occasional fluctuations in the Speed Error resulting in overshoot or undershoot. Thus, the results of this accuracy testing indicate that the developed control system successfully controls the SIMOTICS S-1FL6 servo motor in real-time, resulting in a high level of accuracy and is suitable for applications that monitor pressure from low to high as well as the rate of return from low to high.

Corresponding Author:

Revidadina Dwi Junita

Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang

Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia

Email: revidadinadwijunita@gmail.com

1. INTRODUCTION

As a result of industrial growth, control systems have been created that are not only efficient but also capable of supplying high pressure when actuators, especially servo motors, operate. The process of automated object maintenance and object placement is one of the most critical parts of such systems, because position pressure and speed play a major role in the success of industrial processes [1]. In practice, the Siemens S7-1200 PLC has been widely used in object monitoring and list-making applications due to its ability to integrate with sensors and actuators and provide flexible HMI control [2]. The ability of a servo-based manual release system to precisely reach the target position, maintain a constant speed, and regulate the deviation rate within industrial tolerances is a critical component that requires careful consideration. Although previous studies have shown that Siemens PLC-based pressure control systems enable improved item performance and efficiency over time, they have not comprehensively assessed durability, speed, and position simultaneously [3].

In this regard, the SIMOTICS S-1FL6 motor is the primary choice for servo system development due to its high dynamic performance, precise positional accuracy, and seamless integration with the SINAMICS V90 system. According to Siemens' documentation, this motor is specifically designed for sorting, packaging, and pick-and-place applications, with feedback capabilities provided by a high resolution encoder and a reasonable response time [4]. A manual release system is significantly reduced when the SIMOTICS S-1FL6 and SINAMICS V90 are combined since they may operate in positional (IPOS), speed (Speed), and torque (Torque) modes [5]. As an example, encoderless positioning, or encoderless approach, has also been used in combination with SINAMICS G120 and S7-1200. This suggests that even in many situations when a high

sensitivity is needed, Siemens PLCs can regulate position without the need for external feedback encoders [6]. This emphasizes the necessity of testing the closed servo's true arousal level experimentally, especially when using a manual system that is susceptible to minor problems.

On the other hand, many object-minding systems have been evaluated using common efficiency metrics such as level placement and processing speed [6]. By methodically measuring the final position accuracy (in degrees), actual travel speed (RPM), and exit duration (in milliseconds) of a Siemens S7-1200 PLC-based servo-controlled system and a SIMOTICS S-1FL6 motor, this study attempts to analyze the evaluation in a more precise quantitative manne [7]. Consequently, the objective of this study is to assess the sensitivity of a Siemens S7-1200 PLC-controlled SIMOTICS S-1FL6 servo-controlled motor in a manual release system. Three main areas will be the focus of this study to verify the effectiveness of the PLC-based manual system under current industrial pressures: (1) position accuracy, (2) speed accuracy, and (3) consistency over time. By addressing these areas, this study will provide valuable insights into the performance and reliability of the motor system. Ultimately, these findings will contribute to the optimization of operations in industrial environments, ensuring that the technology meets the ever-growing demands of automation.

2. METHOD

This study uses an experimental engineering approach to assess the accuracy of a SIMOTICS S-1FL6 servo motor controlled by a Siemens S7-1200 PLC in a manual release system. The system uses a closed-loop control architecture, where the motor position and speed are monitored in real-time using an internal encoder and automatically corrected by the PLC [8]. TIA Portal V17 is used for all system configuration and programming, along with ladder PLC programming, a KTP700 Comfort HMI, and SINAMICS V90 PN servo drive parameter settings. Through the HMI, the operator can set the target position or speed and record the correction results during testing [9].

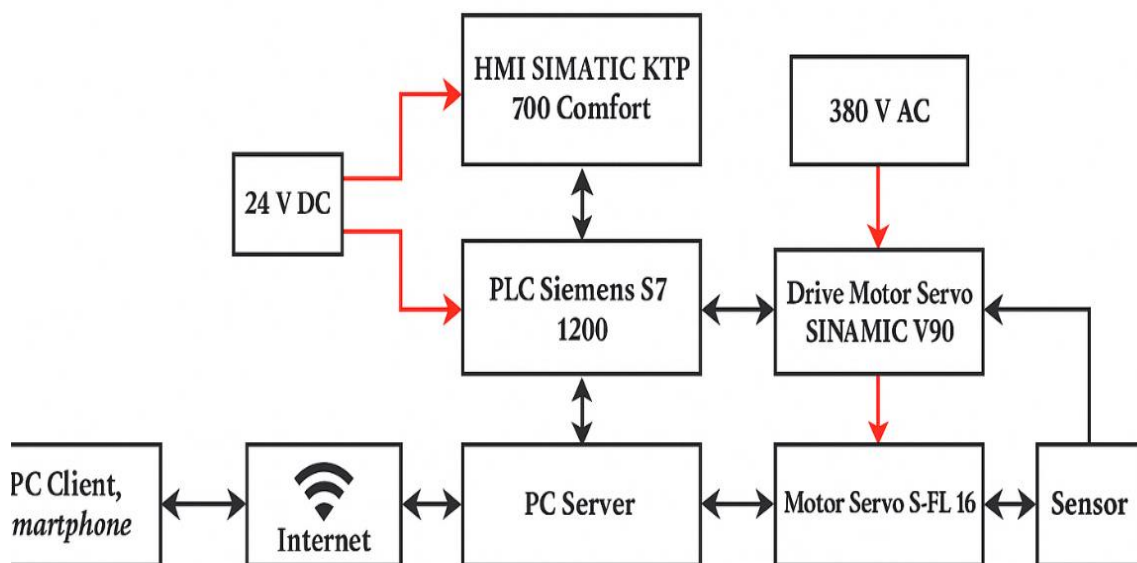


Figure 1. Block diagram of tool design

The PLC is intended to be the primary controller in the system architecture [10]. The PLC sends control signals to the SINAMICS V90 VSD after receiving targets from the HMI and interpreting them using ladder diagrams and logic. This drive then controls the servo motor's power so that it moves in response to the command [8]. The servo motors' high-speed encoders, which offer accurate position and velocity feedback, enable the system to compare target and actual values with precision. This method allows the PLC to automatically control each control segment [11],[12].

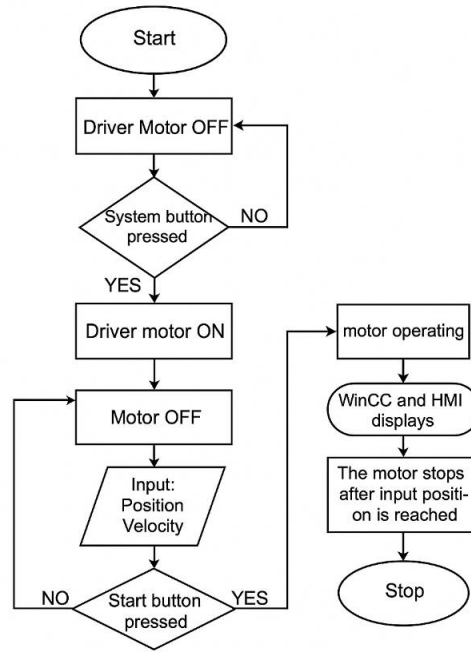


Figure 2. Flow chart of system design

3. RESULTS AND DISCUSSION

Testing was conducted in two main aspects, namely position accuracy and speed. For position accuracy, the motor was driven to a number of target positions (0° , $\pm 90^\circ$, $\pm 180^\circ$, $\pm 270^\circ$, 360°) in CW and CCW directions, including homing, with testing conducted at 10 and 100 RPM. The difference between the target position and the actual position was considered as an error. In contrast, speed testing was conducted in the range of 10 to 100 RPM, where each actual speed was compared with the target to determine the RPM error. The results of this study will be analyzed to determine the maximum and average deviations as a basis for assessing the system's accuracy related to industrial needs in its application.

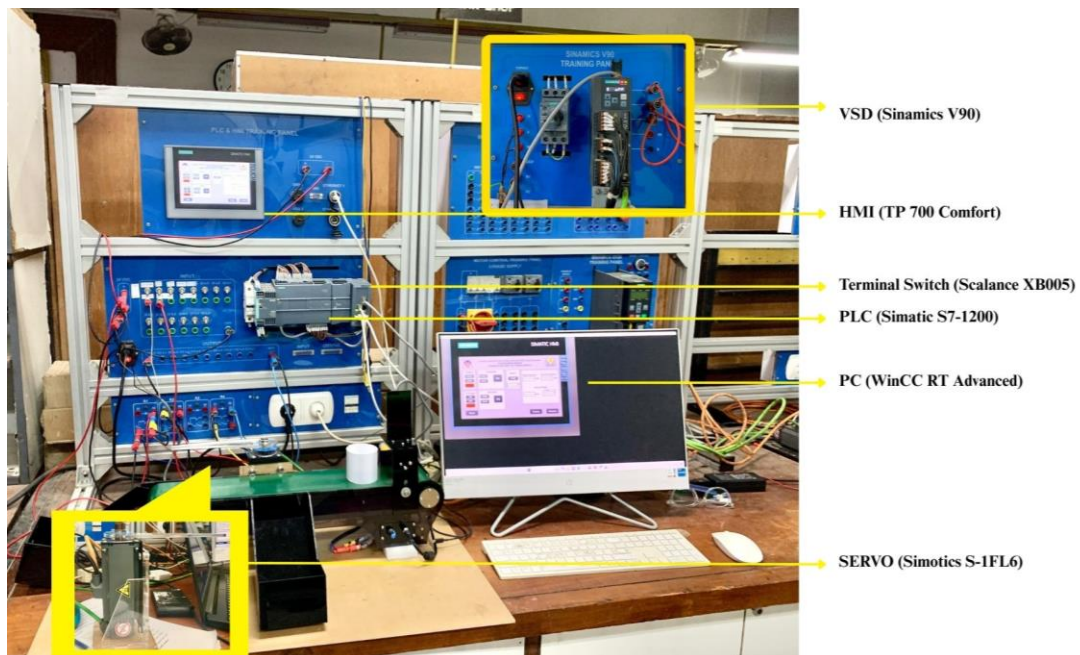


Figure 3. Project tool documentation

The SIMOTICS S-1FL6 servo motor with comprehensive accuracy control and Siemens S7-1200 PLC was tested on a trainer in the energy conversion laboratory. Evaluation focused on motor rotational speed and positioning accuracy. At speeds of 10 RPM and 100 RPM, the accuracy positions were measured at angles of 0°, 90°, 180°, 270°, and 360° in two axes (CW/CCW). Speed accuracy was evaluated on a range of RPM target scales, ranging from 10 to 100. To ensure the objectivity of the evaluation, all data were collected via the HMI and validated using a digital tachometer.

Table 1. Angle accuracy measurement with 10 rpm

No	Target Position	Direction of Movement	Actual Position	Measure ment	Error Difference	Notes
	(Degrees/ Unit)		(Degrees/ Unit)	(Degrees/ Unit)	(Degrees/ Unit)	
1	90	CW	89,964	90,000	0,36	Joging 1
2	180	CW	180,000	180,000	0	Joging 2
3	270	CW	270,000	270,000	0	Joging 3
4	360	CW	360,036	360,000	0,36	Joging 4 (Homing)
5	-270	CCW	270,036	270,000	0,36	Joging -1
6	-180	CCW	360,108	360,000	0,108	Joging -2
7	-90	CCW	90,108	90,000	0,108	Joging -3
8	0	CCW	0	0	0	Joging -4 (Homing)

According to the "SIMOTICS S-1FL6 Servo Test Table (RPM Setting - 10 RPM)" (shown in Table 1), the position accuracy at 10 RPM shows good pressure with varying error margins. The 180° and 270° CW targets have an inaccuracy of 0 [13][14]. However, an error of 36 (0.036°) and an error of -36 (-0.036°) are present at 90° CW and 360° CW (homing), respectively. The CCW movements at -180° and -90° show a consistent error of -108 (-0.108°), indicating deviation or failure to return to the target. Significant positional accuracy at 100 RPM is demonstrated by the "SIMOTICS S-1FL6 Servo Test Table (RPM Setting - 100 RPM)" (seen in Table 2). For a 180° CW target, the largest divergence is -396 (-396°). A 90° CW target has an inaccuracy of -72 (-0.072°). Inaccuracies at 270° and 360° (Homing) CW may approach -360 (-0.360°). Additionally, CCW motion exhibits increasing inaccuracy, peaking at -180 (-0.180°) during jog -4. This indicates the system's inability to maintain pressure and stability at high speeds.

Table 2. Angle accuracy measurement with 100 rpm

No	Target Position	Direction of Movement	Actual Position	Measure ment	Error Difference	Notes
	(Degrees/ Unit)		(Degrees/ Unit)	(Degrees/ Unit)	(Degrees/ Unit)	
1	90	CW	90,072	90,000	0,72	Joging 1
2	180	CW	180,396	180,000	0,366	Joging 2
3	270	CW	270,000	270,000	0	Joging 3
4	360	CW	360,360	360,000	0,360	Joging 4 (Homing)
5	-270	CCW	270,072	270,000	0,72	Joging -1
6	-180	CCW	180,036	180,000	0,36	Joging -2
7	-90	CCW	90,072	90,000	0,72	Joging -3
8	0	CCW	360,180	360,000	0,108	Joging -4 (Homing)

Servo speed analysis based on the "SIMOTICS S-1FL6 Servo Test Table RPM Accuracy Measurement" (shown in Table 3) shows variations in speed errors. The 10 RPM (CW) target has an overshoot speed error of 1,060 RPM. The speed error for the 50 RPM (CW) target is quite large, at -7,160 RPM (undershoot). In contrast, 20 RPM (CCW) has a speed error of only 190 RPM, while 80 RPM (CCW) has a speed error of about 670 RPM. These fluctuations affect the dynamic response and control strategy of the motor in various ways, including speed, load, and friction.

In summary, the SIMOTICS S-1FL6 servo motor controlled by a Siemens S7-1200 PLC delivers a wide range of performance. Position accuracy is good at low speeds, but degrades significantly at high speeds and complex movements. Overall speed accuracy is acceptable, although there is significant vibration at some intermediate points. The system is adequate for medium to high precision at low-medium speeds. However, for applications that are critical to high speeds or sudden movements, control optimization (PID tuning), mechanical calibration, or high-resolution encoders may be necessary to reduce deviations [15].

Table 3. RPM accuracy measurement

No	Target Speed	Direction of Movement	Actual Position	Measurement	Error Difference	Information
	(RPM)		(RPM)	(RPM)	(RPM)	
1	10	CW	10,920	9,860	1,060	Joging 1
2	30	CW	34,840	29,810	5,030	Joging 2
3	50	CW	43,160	50,320	-7,160	Joging 3
4	70	CW	72,280	70,170	2,110	Joging 4
5	90	CW	94,120	91,600	2,520	Joging 5
6	100	CCW	101,180	98,740	2,440	Joging 6
7	80	CCW	80,600	79,930	670	Joging 7
8	60	CCW	61,880	59,240	2,640	Joging 8
9	40	CCW	39,000	35,340	3,660	Joging 9
10	20	CCW	16,640	16,450	190	Joging 10

4. CONCLUSION

This research focuses on the control accuracy of a SIMOTICS S-1FL6 servo motor, operated by a Siemens S7-1200 PLC and a Sinamics V90 VSD with the assistance of an HMI. It is evident from the positioning accuracy evaluation, which is based on several targets (0°-360° clockwise and counterclockwise), that the system can determine the ideal pressure at a speed of 10 RPM. However, this accuracy clearly shows that the speed is increased to 100 RPM, especially when the motor performs more complex movements. On the other hand, a review of the rotational speed accuracy (from 10 to 100 RPM) often shows a strong ability of the system to achieve the target RPM, although there are occasional fluctuations in the Speed Error that are overshoot or undershoot. In summary, these accuracy tests indicate that the developed control system successfully drives the SIMOTICS S-1FL6 servo motor. In essence, this series of accuracy measurements confirms that the developed control system successfully controls the SIMOTICS S-1FL6 servo motor in real-time, offering an adequate level of accuracy for applications demanding medium to high precision at low to medium speed ranges.

REFERENCES

- [1] K. A. Syahputra, F. R. A. Bukit, and Suherman, "Perancangan HMI (Human Machine Interface) Sebagai Pengontrol Dan Pendeteksi Dini Kerusakan Kapasitor Bank Berbasis PLC," *J. Energy Electr. Eng.*, vol. 101, no. 2, pp. 1–9, 2022.
- [2] H. Prakoso Adhi, R. Rizal Isnanto, and B. Sudarsono, "Automasi Sistem Kendali Mesin di Lini Blending 3 Ton PT Djarum Plant OASIS dengan PLC Siemens S7 300 dan Wincc Expoler V7.2," *J. Profesi Ins. Indones.*, vol. 1, no. 4, pp. 139–149, 2023, doi: 10.14710/jpii.2023.20648.
- [3] A. W. Abdul Ali and A. H. Alquhali, "Improved Internal Model Control Technique for Position Control of AC Servo Motors," *Elektr. J. Electr. Eng.*, vol. 19, no. 1, pp. 33–40, 2020, doi: 10.11113/elektrika.v19n1.179.
- [4] J. Ye and X. Gao, "Application Research of Servo Circuit Based on PLC and Configuration Software," *2019 12th International Symposium on Computational Intelligence and Design (ISCID)*, Hangzhou, China, 2019, pp. 3–6, doi: 10.1109/ISCID.2019.00008.
- [5] A. Minsandi et al., "Design and Implementation of Robot Abu Robocon Using Joystik Wireless Based on Extrasensory Perception," *Journal of Industrial Automation and Electrical Engineering*, vol. 01, no. 01, pp. 39–45, 2024.
- [6] M. R. Patel, K. Goswami and M. Tilwari, "Design and implementation system of peeling conventional VFD by servo motor based on PLC," *2017 International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, India, 2017, pp. 575–579, doi: 10.1109/ICCMC.2017.8282532.
- [7] S. Salunkhe and V. N. Kalkhambkar, "VFD Control for Industrial Machines using PLC and LC Filter," *2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICT)*, Kannur, India, 2019, pp. 1653–1658, doi: 10.1109/ICICT46008.2019.8993387.
- [8] D. Shuyu and Z. Linqi, "Research of the Servo Control System of NC Inkjet Printer Based on PLC," *2019 18th International Symposium on Distributed Computing and Applications for Business Engineering and Science (DCABES)*, Wuhan, China, 2019, pp. 238–240, doi: 10.1109/DCABES48411.2019.00066.
- [9] I. Ikhwani and M. Yuhendri, "Penyusunan Jobsheet Kendali Motor Servo Berbasis Human Machine Interface," *J. Pendidik. Tek. Elektro*, vol. 4, no. 1, pp. 350–357, 2023, doi: 10.24036/jpte.v4i1.268.
- [10] E. Vardar, A. H. Giraz, H. Örenbaş and S. Şahin, "OPC server based and real time motor speed control with PLC communication system," *2018 26th Signal Processing and Communications Applications Conference (SIU)*, Izmir, Turkey, 2018, pp. 1–4, doi: 10.1109/SIU.2018.8404624.
- [11] R. Alamsyah, D. M. Gandana, Nasril and D. Astharini, "Implementation of turret system control with induction motor on CNC lathe using PLC Siemens S7-200," *2016 International Symposium on Electronics and Smart Devices (ISESD)*, Bandung, Indonesia, 2016, pp. 214–218, doi: 10.1109/ISESD.2016.7886721.
- [12] Y. D. Satriani and M. Yuhendri, "Kontrol Posisi Motor Servo Berbasis Human Machine Interface dan Internet of Things," *JTEIN J. Tek. Elektro Indones.*, vol. 4, no. 2, 2023, doi: 10.24036/jtein.v4i2.523.

- [13] V. Hristov, "Control of Single-Axis Servo Motor Drive with PLC Controller," *2025 14th Mediterranean Conference on Embedded Computing (MECO)*, Budva, Montenegro, 2025, pp. 1-8, doi: 10.1109/MECO66322.2025.11049233.
- [14] R. Saputra and M. Yuhendri, "Pembuatan Job Sheet Kendali Motor Servo Menggunakan Variable Speed Drive," *J. Pendidik. Tek. Elektro*, vol. 04, no. 01, pp. 117–124, 2023.
- [15] M. F. Işık, M. R. Haboglu and H. Yanmaz, "Monitoring and control of PLC based motion control systems via device-net," *2014 16th International Power Electronics and Motion Control Conference and Exposition*, Antalya, Turkey, 2014, pp. 963-966, doi: 10.1109/EPEPMC.2014.6980632.