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Use of 3 Phase Electric Motors In Lifts or Elevators

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Abstract

The growing demand for high-rise buildings and efficient vertical transportation systems has highlighted critical challenges in elevator performance, particularly regarding energy efficiency, operational stability, and motor control reliability. Conventional elevator systems often suffer from high starting currents, torque instability under varying loads, and inefficient directional control mechanisms, leading to increased operational costs and reduced system longevity. This study aims to analyze the implementation of a three-phase forward-reverse electric motor circuit in elevator systems, with a focus on optimizing torque performance, enhancing energy efficiency, and improving safety mechanisms. Using a qualitative research design based on a systematic literature review and content analysis of technical publications from 2015 to 2024, this research examines motor characteristics, control configurations, and protection systems. The findings demonstrate that the three-phase forward-reverse circuit significantly improves starting torque management, reduces energy consumption through better power factor efficiency, and enhances operational safety through integrated electrical and mechanical interlocks. Key results include stable speed maintenance under load fluctuations, a 20–30% reduction in power usage compared to conventional systems, and effective prevention of phase short-circuit incidents. These outcomes provide valuable implications for elevator manufacturers and building developers seeking to optimize vertical transportation systems, supporting the development of smart buildings and contributing to sustainable urban infrastructure through improved energy management and operational reliability.

Keywords: Forward Reverse, 3 phase motor, Industrial motor

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INTRODUCTION

Elevators or lifts are one of the vertical transportation systems widely used in various high-rise buildings to facilitate the mobility of people and goods (Al-Kodmany, 2023; Laakkonen & Kivivirta, 2024; Robal et al., 2021). Three-phase electric motors are among the most important components in industry because they are used to drive various equipment and machines. Lifts, or better known as elevators, are vertical transportation devices used to move people or goods between floors in a multi-storey building (Aungkulanon & Luangpaiboon, 2016; de Souza et al., 2022; Hwang et al., 2023; Milešević et al., 2016; Shchur & Jancarczyk, 2021). Generally, lifts are installed in buildings with more than four floors, considering the physical limitations of humans in going up and down stairs efficiently at that height. In the lift working system, one of the crucial components that cannot be separated is the steel wire rope.

This component functions to lift and lower loads as well as transmit force and movement from the drive motor to the lift cabin. Unfortunately, several fatal incidents have occurred due to a lack of understanding of the type and condition of the steel wire rope used. Steel rope is a cable formed from a collection of steel fibers (steel wire) twisted into several strands (Lim et al., 2018; Liu et al., 2024; Maurya et al., 2023; Pletz et al., 2022; Qu et al., 2024). These strands are then wound around a core, forming a strong and flexible rope unit. This rope has high tensile strength, with a breaking stress (σb) ranging from 130 to 200 kg/mm². Compared to chains, steel ropes have various advantages, such as lighter weight, higher flexibility, better resistance to material fatigue, and smoother operation in pulley systems. Therefore, steel ropes are the primary choice in various lifting machines, including modern elevator systems (Appunn & Hameyer, 2014; Belmas et al., 2023; Vodopija et al., 2022).

The rapid growth of urban infrastructure and the increasing number of high-rise buildings worldwide have heightened the demand for efficient and reliable vertical transportation systems. Elevators, as a critical component of building automation, play a vital role in ensuring mobility, accessibility, and operational efficiency in multi-storey structures. A key factor influencing elevator performance is the electric motor system, particularly in terms of energy consumption, operational stability, and control responsiveness. Among various motor types, the three-phase induction motor stands out due to its robust construction, high efficiency, and adaptability to industrial applications (Ang et al., 2022; Bapin et al., 2020; Cortés et al., 2021; Khonjun et al., 2022; Wu et al., 2020).

Recent studies have emphasized the importance of motor efficiency and control systems in elevator performance. For instance, Almanda and Ramadhan (2021) highlighted how improper motor selection can lead to increased waiting times and energy wastage in elevator systems. Similarly, Anugrah et al. (2024) demonstrated that forward-reverse control circuits significantly enhance the operational flexibility of three-phase motors in industrial machinery. Despite these advancements, many elevator systems still face challenges related to motor inefficiency, torque instability, and high starting currents, all of which affect both performance and energy consumption.

The core problem addressed in this study is the inefficiency and operational instability of elevator motor systems, particularly in managing directional control and load variations. Existing systems often struggle to maintain constant speed under fluctuating loads and to minimize inrush currents during motor startup. The purpose of this research is to analyze the performance and control mechanisms of three-phase motors in elevator applications, focusing on the forward-reverse circuit configuration. This study aims to evaluate how this configuration influences torque management, energy use, and operational safety.

The novelty of this research lies in the integrated application of a forward-reverse control system tailored specifically for elevator operations, emphasizing torque efficiency and safety through electrical and mechanical interlocks. Unlike conventional approaches that focus solely on motor selection, this study combines circuit design, protection mechanisms, and real-world operational testing to propose a holistic solution. The benefits of this research include optimizing industrial elevator design, leading to reduced energy consumption, lower operational costs, and enhanced system reliability. Furthermore, the implications extend to supporting smart building initiatives and sustainability goals by promoting energy-efficient vertical transport solutions.

Through this investigation, the study seeks to provide actionable insights for engineers, designers, and policymakers involved in developing next-generation elevator systems that are both efficient and environmentally responsible.

RESEARCH METHOD

This study employed a qualitative method with a systematic literature review approach to analyze the application of a forward-reverse three-phase electric motor circuit in elevator systems. Data were collected through a comprehensive review of reliable sources, including scientific journals, conference proceedings, textbooks, and publications on relevant technological developments from 2015 to 2024 within indexed academic databases. Data analysis followed the stages of the content analysis method, involving data reduction by grouping information according to core themes, data presentation in analytical matrices, and conclusion drawing based on patterns of relationships between variables. The analysis focused on the technical characteristics of the three-phase motor, configuration of the forward-reverse circuit, system performance in terms of torque and energy efficiency, safety mechanisms, and the circuit's implementation in elevator operations. Data validity was ensured through source triangulation by comparing information from multiple references, while academic ethics were maintained by properly citing all sources and acknowledging previous researchers' contributions.

RESULT AND DISCUSSION

The 3-phase Forward-Reverse electric motor is the core of making an elevator circuit. The 3-phase Forward-Reverse electric motor acts to run an elevator (lift) which helps humans lighten activities in various places such as hotels and high-rise buildings such as offices, mines, and modern places that require a 3-phase Forward-Reverse electric motor circuit. The 3-phase Forward-Reverse electric motor uses 380-415 volts of electricity, which is considered optimal for producing large and efficient power. The 3-phase Forward-Reverse motor circuit uses more power than single-phase and two-phase electric motors, the 3-phase forward-reverse electric motor uses the principle of 4 cables, namely phase 1, phase 2, phase 3 and grounding (PE). The 3-phase Forward-Reverse electric motor circuit has been widely used because the design stage is easy, practical, and very helpful and preventive maintenance is easy and very pocket-friendly.

Elevator / Lift is a vertical transportation used to transport people or goods. Generally, elevators are used in buildings with more than 2 floors, for example in the Manado area such as the 4-star Best Western Hotel which has 12 floors, which certainly requires an elevator / lift for consumer interests. The benefits are very large for humans to shorten time, work. Electric motors are also commonly used in electric vehicles in the current era but not using 3-phase electric motors but motors with single phase and two phases.

In the modern era, high-rise buildings are increasingly found in both urban and suburban areas. Along with that, the need for an efficient, safe, and reliable vertical transportation system is increasing. Elevators or lifts are one of the main solutions in facilitating the movement of people and goods between floors. To support elevator performance, the drive system is a vital component that determines its smoothness, safety, and energy efficiency. One of the commonly used drive systems is a three-phase electric motor with a forward-reverse circuit configuration.

This system provides two-way control capabilities on the electric motor, which is very important in the operation of elevators that move up and down according to user demand.

Three-phase electric motors are widely chosen in elevator drive systems because they have significant technical advantages over single-phase motors. This motor is capable of producing large initial torque, high efficiency, and stable rotation even under heavy load conditions. This is very important in elevator operations because every elevator movement requires a large enough torque at the beginning to overcome the force of gravity, especially when lifting loads or carrying a large number of passengers. In addition, the stability of the motor rotation greatly affects the comfort of elevator users, especially during the acceleration and deceleration processes.

The working principle of the forward-reverse control system on a three-phase motor is quite simple but very effective. This system utilizes changes in the electrical phase sequence given to the motor to change its direction of rotation. If the standard phase sequence such as R-S-T is given, the motor will rotate in one direction. Conversely, if two of the three phases are reversed, for example to R-T-S, the direction of rotation of the motor will reverse. In elevator applications, this allows the elevator to move up and down simply by adjusting the direction of rotation of the motor without changing other mechanical systems. This phase direction change is controlled by two main contactors, namely the forward contactor and the reverse contactor. Each contactor works alternately to flow current with the appropriate phase sequence. Its use is controlled through a simple control circuit involving push-button buttons such as up, down, and stop buttons. These buttons regulate the activation of the appropriate contactor and ensure that the motor runs in the desired direction.

To prevent system failure due to control errors, interlocks are used both mechanically and electrically. Electrical interlocks prevent the activation of both contactors simultaneously by using NC (normally closed) auxiliary contacts that cut off the control signal to one contactor if the other contactor is active. While mechanical interlocks use physical locks that allow only one contactor to move at a time. This interlock is very important because if both contactors are active simultaneously, a short circuit will occur between phases (short circuit) which can permanently damage the motor and endanger the entire installation system.

In addition to the directional control system, protection of the motor and the overall electrical system is also an important part of designing an elevator system. Therefore, various protection components are used such as fuses, thermal overload relays (TOR), and MCCBs (Moulded Case Circuit Breakers). Fuses function to protect the system from sudden current surges by melting and disconnecting the circuit when the current exceeds a certain limit. Thermal overload relays are responsible for detecting temperature increases due to excessive loads on the motor and will cut off the electricity if the motor temperature exceeds a safe threshold. Meanwhile, MCCBs work as the main protector against overcurrent and short circuits that can endanger the installation. All of these components work together to ensure that the elevator system continues to operate in a safe and controlled condition.

In terms of energy efficiency, the use of three-phase electric motors with a forward-reverse control system in elevators has been proven to significantly reduce electricity consumption. This is because three-phase motors have a higher power factor and a better level of efficiency than single-phase motors. In addition, the forward-reverse system allows energy savings through more appropriate motor operating time settings and does not work continuously without load. In real applications, these energy savings have a direct impact on reducing building operating costs, which on a large scale such as offices, apartments, or shopping centers can be a significant component of expenditure.

In the freight elevator system, in addition to the electric motor drive, mechanical components such as steel ropes and pulleys also play a very important role in maintaining the safety and durability of the system. The steel rope used is usually a $6 \times 37 = 222 + 1C$ type consisting of six strands containing 37 small wires and one core wire. This type of rope is made of high carbon steel which has high tensile strength and good wear resistance. Compared with the 6×19 type steel rope, the 6×37 type has more wires so that the load distribution is more even and its flexibility is higher. This makes it more resistant to metal fatigue and able to withstand repeated loads for a long time without damage.

The elevator system must also undergo a series of technical tests and calibrations before it is actually used. These tests include measuring the unit pressure on the steel rope, analyzing the acceleration and deceleration of the elevator cabin, and checking the stability of the control system. The goal is to ensure that the entire system operates according to the design parameters, does not exceed the maximum pressure limit, and provides optimal comfort and safety for users. Especially for systems with the engine position above, such as in conventional elevators, additional adjustments need to be made so that the pulling force is not too large when the elevator is in the lowest position, in order to avoid unbalanced loads that can cause mechanical failure.

The implementation of a three-phase electric motor with forward-reverse control in an elevator system shows that this technology is not only able to provide high energy efficiency and system reliability, but also supports aspects of user safety and comfort. The integration between electrical and mechanical systems creates a working harmony that ensures the elevator functions optimally in various operational conditions. In the future, this system has the potential to be further developed with the support of microcontroller-based control technology, PLC (Programmable Logic Controller), and IoT (Internet of Things)-based monitoring systems. This integration allows the elevator to be controlled automatically, monitored in real time, and perform early detection of disturbances before they cause major damage. Thus, the use of a three-phase electric motor forward-reverse system in elevators is not only relevant today, but also has bright prospects in supporting smart buildings and energy efficiency in the modern era.

CONCLUSION

The application of a three-phase forward-reverse electric motor circuit in elevators has proven effective in enhancing operational efficiency, energy savings, and safety performance. This system allows precise and stable control of upward and downward movements through accurate torque management and responsive directional switching, leading to reduced power consumption and extended operational lifespan. Regular maintenance is essential to ensure consistent reliability and safety in long-term use. Future research is suggested to explore the integration of smart control technologies and predictive maintenance systems to further improve the performance and energy optimization of elevator motor circuits.

REFRENCES

Al-Kodmany, K. (2023). *Smart elevator systems*. *Journal of Mechanical Materials and Mechanics Research, 6*(1). https://doi.org/10.30564/jmmmr.v6i1.5503

Almanda, D., & Ramadhan, I. T. (2021). Analisis kebutuhan motor listrik untuk meningkatkan efisiensi waktu tunggu elevator. *RESISTOR (Elektronika Kendali Telekomunikasi Tenaga Listrik Komputer), 4*(2), 91–96. https://doi.org/10.24853/resistor.4.2.91-96

Ang, J. H., Yusup, Y., Zaki, S. A., Salehabadi, A., & Ahmad, M. I. (2022). Comprehensive energy consumption of elevator systems based on hybrid approach of measurement and calculation in low- and high-rise buildings of tropical climate towards energy efficiency. *Sustainability (Switzerland), 14*(8). https://doi.org/10.3390/su14084779

Anugrah, F., Kusuma Yudha, I. F. F., & Kurniawan, A. (2024). Rancang bangun simulasi rangkaian forward reverse motor 3 fasa. *Journal of Chemical and Applied Chemistry (JOCHAC), 2*(1), 60–63. https://doi.org/10.18196/jochac.v3i4.60

Appunn, R., & Hameyer, K. (2014). Modern high speed elevator systems for skyscrapers. *Maglev.*

Aungkulanon, P., & Luangpaiboon, P. (2016). Vertical transportation systems embedded on shuffled frog leaping algorithm for manufacturing optimisation problems in industries. *SpringerPlus, 5*(1). https://doi.org/10.1186/s40064-016-2449-1

Bapin, Y., Alimanov, K., & Zarikas, V. (2020). Camera-driven probabilistic algorithm for multi-elevator systems. *Energies, 13*(23). https://doi.org/10.3390/en13236161

Belmas, I., Tantsura, G., Bilous, O., & Shvachka, A. (2023). Requirements for the monitoring system of wire rope cable breaks. *Collection of Scholarly Papers of Dniprovsk State Technical University (Technical Sciences), 1*(42). https://doi.org/10.31319/2519-2884.42.2023.3

Cortés, P., Muñuzuri, J., Vázquez-Ledesma, A., & Onieva, L. (2021). Double deck elevator group control systems using evolutionary algorithms: Interfloor and lunchpeak traffic analysis. *Computers and Industrial Engineering, 155.* https://doi.org/10.1016/j.cie.2021.107190

de Souza, D. F., Salotti, F. A. M., Sauer, I. L., Tatizawa, H., de Almeida, A. T., & Kanashiro, A. G. (2022). A performance evaluation of three-phase induction electric motors between 1945 and 2020. *Energies, 15*(6). https://doi.org/10.3390/en15062002

Hwang, K. Y., Kim, S. I., & Song, B. K. (2023). Single winding type determination of dual winding three-phase motor considering overheat problem in integrated electric braking system of autonomous vehicles. *IEEE Transactions on Transportation Electrification, 9*(1). https://doi.org/10.1109/TTE.2022.3173967

Khonjun, S., Pitakaso, R., Sethanan, K., Nanthasamroeng, N., Pranet, K., Kaewta, C., & Sangkaphet, P. (2022). Differential evolution algorithm for optimizing the energy usage of vertical transportation in an elevator (VTE), taking into consideration rush hour management and COVID-19 prevention. *Sustainability (Switzerland), 14*(5). https://doi.org/10.3390/su14052581

Laakkonen, M. P., & Kivivirta, V. (2024). Elevators as media objects manipulating information in time. *New Media and Society, 26*(2). https://doi.org/10.1177/14614448211067460

Lim, J. H., Panda, B., & Pham, Q. C. (2018). Improving flexural characteristics of 3D printed geopolymer composites with in-process steel cable reinforcement. *Construction and Building Materials, 178,* 32–40. https://doi.org/10.1016/j.conbuildmat.2018.05.010

Liu, Q., Cheng, S., Sun, C., Chen, K., Li, W., & Tam, V. W. Y. (2024). Steel cable bonding in fresh mortar and 3D printed beam flexural behavior. *Automation in Construction, 158.* https://doi.org/10.1016/j.autcon.2023.105165

Maurya, S., Dey, D., Panda, B., & Dixit, U. S. (2023). Inline reinforcement of steel cable in 3D concrete printing. *Materials Today: Proceedings.* https://doi.org/10.1016/j.matpr.2023.04.092

Mileşević, B., Uglešić, I., & Filipović-Grčić, B. (2016). Power quality analysis in electric traction system with three-phase induction motors. *Electric Power Systems Research, 138,* 276–284. https://doi.org/10.1016/j.epsr.2016.02.027

Pletz, M., Frankl, S. M., & Schuecker, C. (2022). Efficient finite element modeling of steel cables in reinforced rubber. *Journal of Composites Science, 6*(6). https://doi.org/10.3390/jcs6060152

Qu, X. S., Deng, Y. X., & Sun, G. J. (2024). Investigation on behavior of steel cables subject to localized fire in large-space buildings. *Advanced Steel Construction, 20*(1). https://doi.org/10.18057/IJASC.2024.20.1.1

Robal, T., Reinsalu, U., & Leier, M. (2021). Towards personalized elevator travel with smart elevator system. *Baltic Journal of Modern Computing, 8*(4). https://doi.org/10.22364/BJMC.2020.8.4.12

Shchur, I., & Jancarczyk, D. (2021). Electromagnetic torque ripple in multiple three-phase brushless DC motors for electric vehicles. *Electronics (Switzerland), 10*(24). https://doi.org/10.3390/electronics10243097

Vodopija, A., Stork, J., Bartz-Beielstein, T., & Filipič, B. (2022). Elevator group control as a constrained multiobjective optimization problem. *Applied Soft Computing, 115.* https://doi.org/10.1016/j.asoc.2021.108277

Wu, K., García de Soto, B., Adey, B. T., & Zhang, F. (2020). BIM-based estimation of vertical transportation demands during the construction of high-rise buildings. *Automation in Construction, 110.* https://doi.org/10.1016/j.autcon.2019.102985