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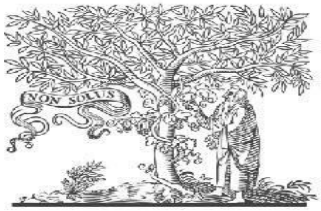

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# Fuzzy Logic Control for Solar PV Fed Modular Multilevel Inverter applied to Marine Water Pumping

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**Abstract**

The aim of this project is to design and use the program to create a Modular Multilevel Inverter (MMI) for controlling an induction motor. of intelligent control techniques. Inverters of eleven levels are proposed for controlling the the rate of a solar-powered IM drive. According to estimates, nearly 50% of the energy used on board ships is consumed by pumping schemes. In light of this, this study investigates and evaluates a suggested control architecture for marine water pumping systems that use induction motors (IM) and Modular Multilevel Inverter. Fuzzy Logic (FL) and Proportional-Integral (PI) based controllers were used to analyze the performance of the inverter. Using the parameters of peak overshoot, inverter settling time, and total harmonic distortion (THD), a comparative analysis is conducted to determine which inverter has a better robustness. The conceptualization and incorporation of an Modular Multilevel Inverter, an Induction Motor, and a control system tailored to marine water pumps is an original aspect of our control scheme.

**Keywords:** Modular Multilevel Inverter (MMI), Induction Motor (IM), Fuzzy Logic, Proportional Integral(PI), Total Harmonic Distortion.

## Introduction

In around the world, extensive endeavours been taken by the oceanic and delivery ventures to decay the degree of environmental discharges and utilization of energy. Specific principles are presented for avoiding the occurrence of pollution in the ocean climate and coincidental factors. by Worldwide Show for the Anticipation of Contamination from Boats association (MARPOL).The environmental change and worldwide ozone depleting substance emanations transporting contribute around 3% of worldwide CO2 discharges from diesel motors engaged with marine areas .The marine transportation diesel motors emanates ,the primary pollutants are 2.8% atmospheric carbon dioxide (CO2), 15% nitrogen oxides (NOX), and 13% sulfur oxides (SOx). gases for causing the global warming and to contaminate the air resulting many problems.

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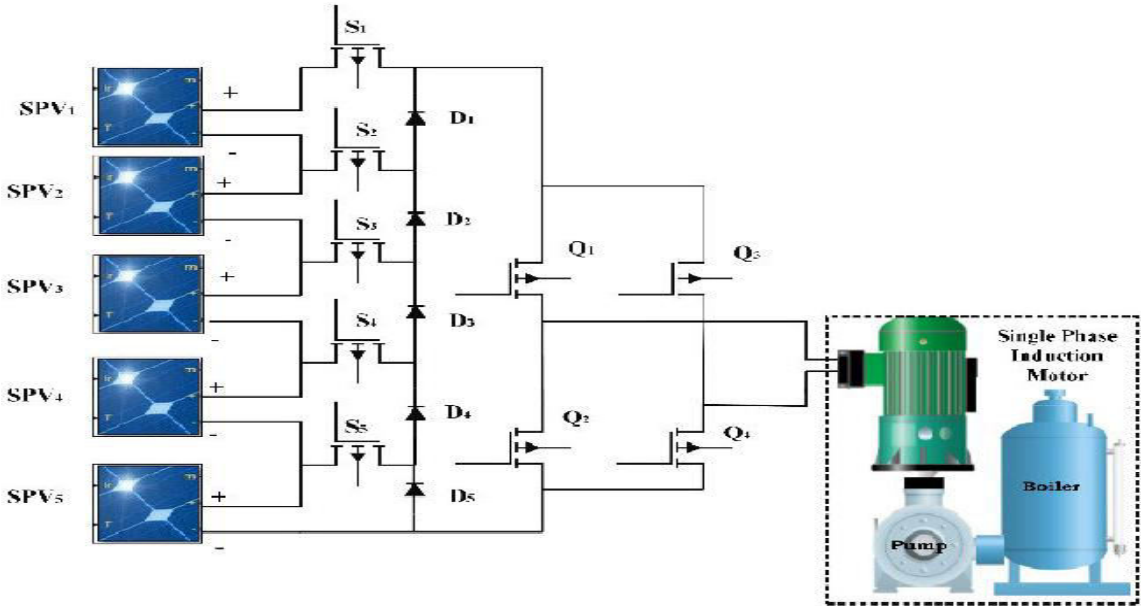


Figure 1- Diagram of the planned multilayer inverter

The use of diesel motors in the boat emanates ozone depleting substance and CO2 discharges are continuously expanded also, it is firmly expected to arrive at 8% in the year 2020. To conquer the issues looked due to ecological contamination in the boat business, an upset advanced towards the execution of sun-based ability to give clean power from environmentally friendly power energy sources. Despite a growing global need for electricity increasing worldwide interest for electricity attributable to expanding overall populace, the general craving for sun based energy alongside further developed power nature of an inverter are the need of great importance. The consumption of traditional energy sources causes the developing worldwide energy emergency. Nonetheless, it additionally results in the nursery impact prompting a worldwide temperature alteration. Sunlight based power is typically the most ideal decision for the vast majority of the rural and maritime applications because they need fewer resources, offer commotion free tasks due to the shortfall of moving parts and consumes less space at roofs in the boat.The photovoltaics-based energy framework is implemented in transportation, which transmits power integrating a creative technique to reduce emissions, boost environmentally friendly power productivity, and furthermore to liven up the force. To transmit various high power demands, the solar energy source is coordinated with a power electronic converter and inverter. The two main concerns that occurred with power converters were voltage diversion and recurrence variations, which resulted in music mutilation. The siphoning frameworks in the boat con-

sume roughly 70% of in general electrical energy. In transport power hardware, The converter is an important component used for the impulse of engine drives frameworks, but it suffers greatly from the loss of music. The suggested study investigates new advancements, namely an inverter, which is used to improve the quality of power in the boat by reducing noise with the assistance of a clever regulator. The research proposes a smart symmetric staggered module based on overflow class that does not require any additional circuit to generate negative voltage levels. The inverter is used to power the variable recurrence drive of the boat's seawater cooling siphon. The performance of the interleaved inverter used for IM drive is investigated using PI and FLC-based regulators. Because of its superior most extreme top overshoot and strength, the relative-vital regulator is used in the majority of speed control applications. Fuzzy Logic Control is the easiest of all intelligent regulator for acceptable engine rate control applications.

**Literature Survey**

**H. Lan, Y. Bai, S. Wen, D. C. Yu, Y.-Y. Hong, J. Dai, and P. Cheng**:

'With increasing concern over major impacts on the environment and conventional energy use, the incorporation of solar generating into maritime electrical systems has gained prominence. However, the penetration of solar energy would end up resulting in shipboard power system destabilization due to sun irradiation uncertainty. The electricity provided by solar energy systems on the onboard fluctuates as the ship rolls, unlike on land. A high-speed revolving energy storage system (FESS) is simulated in this article to smooth PV power oscillations and enhance power quality on a big oil tanker with a PV production system, a diesel engine, a FESS, as well and different kinds of marine loads. Furthermore, to regulate the torque angle, a steady torque orientation regulation technique paired with a sinusoidal pulse width modulating (SPWM) approach is provided loading and emptying of the FESS. The simulation findings show that the fly-wheel storage mechanism for energy is very efficient and responsive, which improves the reliability of the projected composite ship power structure.

**S. G. Jayasinghe, L. Meegahapola, N. Fernando, Z. Jin, and J. M. Guerrero**

The ship microgrids have lately gained popularity, owing to the widespread usage of power-electronic-interfaced loads and sources. These microgrids have properties comparable to landed terrestrial microgrids, with the exception of the existence of extremely dynamic significant loads, such as propulsive loads. In ship microgrids, the existence of these kinds of loads and sources with energy-electronic converters interfaces causes severe power quality difficulties. These problems may be divided into three categories: voltage changes, frequency variations, and waveform distortions, sometimes known as harmonic distortions. Energy storage is

regarded as the most promising technique for mitigating voltage and/or frequency variations among the options identified. Passive filtering, which needs large capacitors and inductors, is the most often used approach for decreasing harmonic distortions.Active filtering is developing as an option that may be realized even inside the same energy storage system's interface converter. The purpose of this study is to investigate current advancements in these areas and give readers with a critical evaluation of power quality challenges, energy storage technologies, and techniques for improving power efficiency on ship microgrids. The study also includes a basic introduction to ship electrical system designs.

**Problem Identification**

The seawater is persistently siphoned from dawn until dusk. Consequently, the beginning current also, preset voltage of an acceptance engine must be kept up with fittingly by controlling the inverter. Regular DC engines have replacement issues. To conquer the disadvantage of DC engine, enlistment engine is exceptionally liked in the boat. The seawater siphons satisfactorily and fulfils the requirements for the appropriate cooling of the new water. The suggested study effort handles a single stage Induction motor drive for sea water siphoning, carried out with Modular Multilevel inverter geography in supported control strategies. The constant execution of rate control is represented by greatest sunlight based power generation in the air conditions. Moreover, the exchanging recurrence is continuously differed from the inverter is to control the speed of an enlistment engine. Accomplished by advanced Heartbeat Width Regulation , which is established with the assistance of a leveling signal created for a FL limiter in order to improve power quality. The recreation research includes the plan of sun-oriented PV took care of Modular Multilevel Inverter fuelling an Induction Motor drive with PI and FLC regulators to improve the general presentation of the framework. The model is created with regulator which creates the fundamental heartbeats for both invertering device and converting device associated with the framework.

The paper's commitments are represented as underneath:

• Examining the exhibition of Propotional Integral and Fuzzy Logic Controller to Induction Motor drive framework for maritime water siphoning

• Relative investigation of Fuzzy Logic and Propotional Integral based regulators in the direction of presentation improvement in moving along power quality.

**Methodology**

The suggested architecture uses PI and FL controllers to regulate the MMI. In order to run PWM manages alternating patterns of an inverter with the use of advanced control techniques in layered inverters and regulates the rate of induction motors.. Analysis is done on the effectiveness of Induction Motor using PI and FL

controllers with looping and sealed-loop procedures with steady and fluctuating loads.

**[1] PI Controller**

The PI and FL controller development and execution for enhancing the performance of an induction motor drive operating in conjunction with Modular Multilevel inverter are described in the following sections.

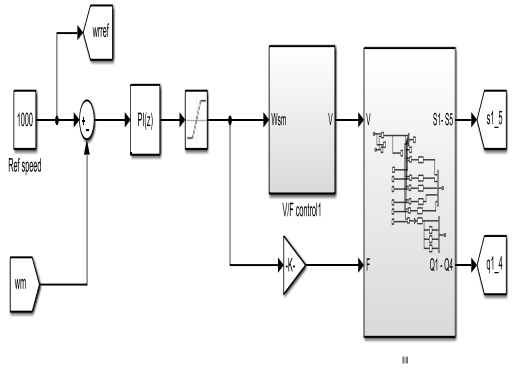


Figure 2 - Controlling part of PI

Most commonly, to build PI-based controllers, one of the three ways through experimentation, adaptive techniques-based search, Cohen Coon, Lambda tuning, or Ziegler Nichols is utilized.. When comparing several techniques for fine-tuning PI controllers, the trial-and-error approach is chosen since it has many advantages for figuring out boost setups and outperforms in motorized operating purposes. By comparing the reference (Wrm) and real (Wrm*) speeds, the comparator typically determines the error (We(n)) that is needed to adjust the parameters Kp and Ki.

We(n) = Wrm – Wrm* is the error equation (We(n))

Two crucial variables in determining the proportional and integral gain for motor drive applications were the major focus of the trial and error procedure. Kp and Ki have been calculated using the trial-and-error approach to have numerical values of 50 and 2, respectively. In order to improve driving performance, the PI controller's goal is to reduce error. In terms of managing the speed of an induction motor while maintaining a constant torque, the closed loop PI controller's goal performs better. The v/f approach is used to operate the proposed inverter switches (Q1, Q2, Q3, and Q4) and switches (S1, S2, S3, S4, and S5). While the other switches Q1 to Q4 convert Input for the IM drive is provided by the output of the inverter with constant v/f. There are various restrictions on the open and closed control operation with PI controllers, such as the rotation rate of the rotor being slightly adjusted and less than the synchronous rate, the current through the stator exceeding the rated current, and slip speed being insufficient.. These PI controller flaws are mostly present under operating situations that are subject to change. FLC gets around this PI controller restriction.

**[2] Fuzzy Logic Controller**

The use of fuzzy logic controllers to analyze speed controllers quickly while adding human thought and rule-based procedures is a very effective method of improving ectrical devices. Induction motors

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are commonly regulated in three ways: (1) raw data into usable/frequency strategy, (2) vector control technique, and (3) flux control method. The enclosed loop v/f control is popular due to its ease of use and great accuracy. method is regarded as the finest among speed control techniques. The two key duties that the suggested FLC is meant to address are

(1) Predicting induction motor rate and (2) Decreasing speed fault utilizing a rules-based approach while simultaneously degrading harmonics. The FLC contains a pair of inputs along with one exit by layout. The modulating signal is treated as the output, with the input is the fault and the alteration in fault rate.. The four processes that FL controller primarily follows are:

(1) The analog fuzzifier generates fuzzy parameters via input

(2) Retains ambiguous rules

(3) Reasoning and associated laws

(4) The defuzzifier converts the fuzzy variables to the true target variables.

| e/ce | NB | NS | ZE | PS | PB |
|---|---|---|---|---|---|
| NB | ZE | NS | NB | NB | NB |
| NS | ZE | NS | NB | NS | NB |
| ZE | PB | PS | ZE | NS | NB |
| PS | PB | PS | PS | ZE | NS |
| PB | PB | PB | PB | PS | ZE |

Table 1 – Fuzzy rule table

The fuzzy rules are shown in Table 1. The input to the fuzzy operator comprises more than one association scores from fuzzifier variables that are being used. The outcome is only one truth value. If input 1 is chosen to symbolize the error, it is correct; nevertheless, the second input depicts the altering error. The elements of language are separated into eight fuzzy segments.

Table 1 depicts the reasoning for controlling the speed using a rule matrix.

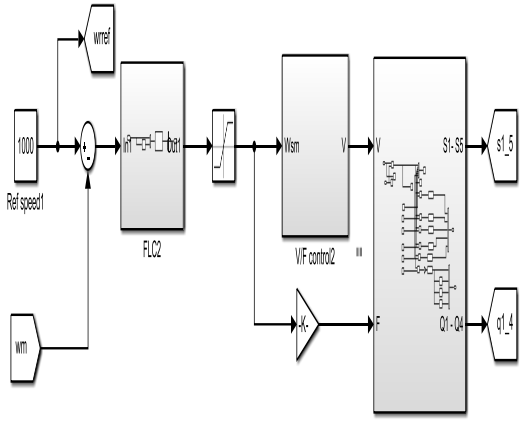


Figure 3 -Controlling part of FLC

The 11-level MMI contains 9 semiconductor switches (S1-S5) that are linked in parallel to switches of H bridges (Q1-Q4). Based on the fuzzy rules, the bipolar triangle and sine wave are compared to create the PWM. S1-S5 pulses are inverter control pulses, while Q1-Q4 pulses are pulses for level management. The switching pattern of the the FLC technique structure is entirely developed. inverter utilizing a switching pulse generator. With a shifting amplitude range of (1, 0). The initial and the second quarter cycles are represented by the positive range from 0 to 1. (0 -90 and 90 -180, respectively).

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Similarly, the inverse of the range from 1 to 0 corresponds to the third quarter cycle (180 -270) and the final quarter cycle (270 -360). Subsequently, six fuzzy-rule-based membership functions are used in defuzz-ification. are built to produce the required result. The article demonstrates the de-sign and development processes. of two control devices for the use of water pump-ing. The inverter is controlled by the volt-age and frequency. The v/f technique is used to regulate the speed of an induction motor.

**Simulation and Results**

To contrast the conduct of PI and FLC controller, a simulation model was creat-ed in MATLAB/Simulink 2018. For open and closed loop operation, the study for harmonics reduction is also conducted. The pump and IM drive are coupled, and the IM drive's designed speed range is 0 to 1000 rpm. PI has higher overshoot, un-dershoot, and steady-state fault parame-ters that must be fulfilled to achieve the goal speed than FLC. Both controllers are tested at a reference speed of 1000 rpm. It should be noted that FLC-based IM drive systems attain the required speed in the shortest period possible. Figure 4 depicts the simulation outcome utilizing a PI con-troller. It demonstrates that the motor be-gins at 0s and settles at 1000 rpm after nearly 2 seconds. When utilizing the FL controller, the motor starts at 0 seconds and stops at 0.5 seconds, as shown in the below Figure 5

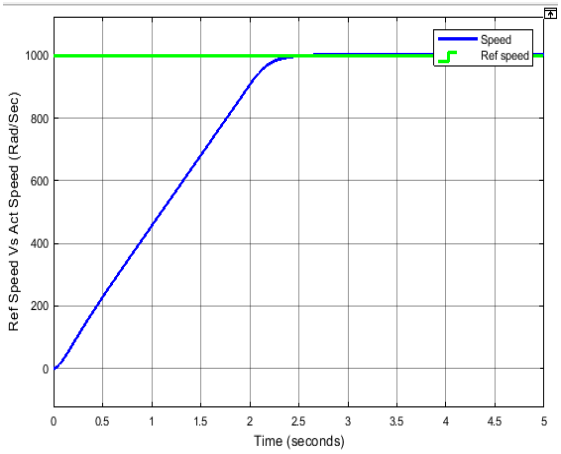


Figure 4 – Response time of PI con-troller

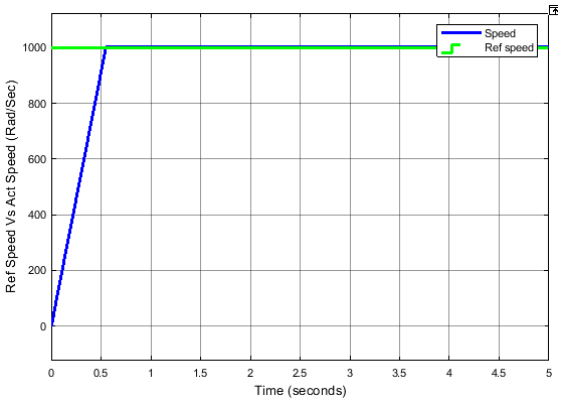


Figure 5 – Speed response of FLC

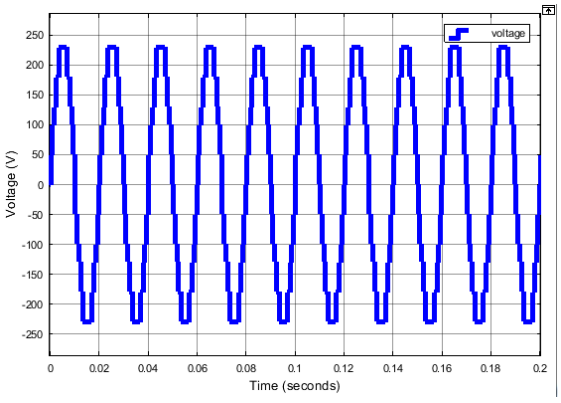


Figure 6 – Voltage waveform output

**Conclusion and Future Scope**

The proposed work is pertinent for appli-cations involving maritime water pump-ing, as it would provide the inverter drive with high-quality power as input .In order

to determine if a fuelled by solar PV Inverter with modular multilevel control for induction motor speed control drive is appropriate for water pumping systems designed for maritime applications, steady state and dynamic behaviors have been explored. The suggested inverter is linked to the solar PV array, which is subsequently supplied to an induction motor. The controller receives data on the motor speed in order to provide the best PWM pulses for the inverter switches. With the help of PI and FL based controllers, the motor is started gradually and the speed is increased to reach the reference speed. The proposed work is pertinent because it would supply high-quality input power to the inverter drive for applications involving marine water pumping. In order to determine if a solar PV fed MMI for speed control of induction motor drive is appropriate for water pumping systems designed for maritime applications, steady state and dynamic behaviors have been explored. The suggested inverter is linked to the solar PV array, which is subsequently supplied to an induction motor. The controller receives data on the motor speed in order to provide the best PWM pulses for the inverter switches. With the help of PI and FL based controllers, the motor is started gradually and the speed is increased to reach the reference speed. A microgrid is typically described as a standalone autonomous system that produces electricity for the entire neighborhood as well as its surrounding areas. The complete DC microgrid component listed is present and functions properly in the proposed system. The future scope is a proper estimation of power generated and electricity utilized.

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