RESEARCH PAPER

Mathematical Modeling and Performance Analysis of a Three-Phase Induction Motor Using LabVIEW

Dr. L. Nagarajan[1], A. Arthi[2], Dr. A. Nazar Ali[3]

[1]Associate Professor, Department of Electrical and Electronics Engineering, Karpagam Institute of Technology, Coimbatore
Corresponding author: nagarajanl.eee@karpagamtech.ac.in

[2]Department of Information Technology, Karpagam College of Engineering, Coimbatore, Tamilnadu, India
Email: arthi.a@kce.ac.in

[3]Professor, Department of Electrical and Electronics Engineering, Rajalakshmi Engineering College, Rajalakshmi Nagar, Thandalam, Tamilnadu
Email: nazarali.a@rajalashmi.edu.in

ABSTRACT
In this article discussed modelling of electrical vehicle and developed modelling of three phase Alternating Current Induction motor (ACIM) using Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW). Developed the mathematical model of ACIM and analysis the simulation linear parameter variable. The constant variable parameters feed to the input of ACIM to produce the result performance in LabVIEW scope. The output of the LabVIEW file feed to the controlling Electrical motor and Simulate real time FPGA trainer kit. The kit composing a real HIL with input and output modules. The input of the ACIM considered various factors, such as speed 1500 RPM of IM, amplitude of each phase is 200 volts, change in time period 2x10-6, and samples of 30,000. Further stator and rotor temperature was considered as 298.15K. In addition with define the number of 4 poles, stator and rotor leakage inductance, magnetizing inductance, stator and rotor resistance value and temperature coefficient value were considered. The simulation outcomes of the voltage, current and torque indicate the performance of ACIM exhibits excellent modelling with numerous inputs.

Keywords:
Alternating current Induction motor, LabVIEW, Modelling of ACIM, Electrical Drives
How to cite this article: Nagarajan L, Arthi A, Nazar Ali A. Mathematical Modeling and Performance Analysis of a Three-Phase Induction Motor Using LabVIEW. Int J Drug Deliv Technol. 2026;16(57s): 17-24. DOI: 10.25258/ijddt.16.57s.3

1. INTRODUCTION

Day by day reserves of petroleum are reduced. The depended of the conventional or petroleum vehicle are tough to do alternative way for running vehicle [1]-[6]. In another side the automobile industry produce more carbon dioxide emission. It directly affect to the animals, plants, etc [2]-[7]. and indirectly makes causes in terms of noise, pollutions, etc[3]-[9]. More percentage of people are dependent on the vehicle for travel short distance, due to these laziness the lifespan effect on another side [4]-[8]. The simplest alternative solution is renewable energy based operation of vehicle. Recent days the renewable energy blooms on most part of the world, the energy such as solar, wind, bio mass, bio gas, etc [5]-[10]. Out of all the renewable energy source, the solar energy available on all the days throughout of the years. The solar energy available on all the places. The average sunshine hours in an India is 6 hours. Roughly 600 to 850 watts per square meter irradiance reach on the surface. The sunshine hours all over the world are more so no problem for charging the electrical vehicle. Based on the concept recent days electrical solar chagrining station are blooms recent days throughout of the world [11]-[16]. The electrical mobility is a good choice for reduce the pollutions as well reduce the dependency of the conventional fuels [12]-[18]. Most of the industry concentrate on develop electrical vehicle such as tata motors, mahendra, tesla, etc.

Outlook of the electrical vehicle as follows [13]-[17]. EV is one of the distributive technology and burl supply chain, such as BMS, battery of lithium and other parts from various parts of the country [14]-[19]. When looks the history of electrical vehicle. In 1910 the

most promising types of vehicle. In 1930 almost not produced any more of the vehicle. 1910 used dawn, 1930 used on oblivion. Three modes of vehicle transport on the early days such as horse cart, IC engine, dawn. In 20th century includes urban mass transit, electric railroads, lift trucks, and golf carts [15]-[20].

Driver for electrical vehicle revival. Such as climate change reduced CO2 emission, oil economy dependence on import bill reduced, energy integration with non-conventional energy sources, energy efficiency and futuristic connected autonomous [16]. 82% of the energy getting from fossil fuel based power generation. The conventional fuel energy source produced more heat. It around of 1.2 degree Celsius. It lead more challenges on flood situation, tsunami. It effect property damage and lungs damage, etc. So how to convent fossil based economy to renewable based economy [7]. The determined the coal. 30 by 30. That means 30% of vehicle should be Electrical vehicle at the end of 2030.

2. METHODOLOGY

Most mainly used EV motors such as Switched Reluctance Motor (SRM), Permanent Magnet Synchronous Motor (PMSM), three phase Induction motor. Control and design using LabVIEW simulation which contains an electrical motor toolkit. The electric motor simulation toolkit contains a motor model, test control algorithms, simulate the motor in real time using FPGA targets and finally build a real time HIL model. PMSM similar to BLDC motor. Which is use in the traction purpose, it includes high power density and high efficiency. The PMSM produces sinusoidal back emf. Trapezoidal shaped back emf produce on BLDC compare with PMSM. High power and performance use on PMSM. It is use on high power electrical car, bus, etc. It is costly compare with BLDC motor. Fixed voltage and frequency operation works on three phase induction motor. The three phase IM has variable controlling techniques. The Squirrel cage induction motor has good life span, less maintenance, but it has complex control circuit compare with PMSM. Because for electrical vehicle application, the DC battery source converter into AC by using inverter circuit and control algorithm. Tesla and mahendra electrical vehicle use on the induction motor. Switched Reluctance motor is simple construction and robust nature. It does not contains any permanent magnet internal intarsia, high acceleration and high speed application and high power density.

Table-1 Motor Simulation Models

	Constant Parameter Model	Variable parameter model	FEA Model
Requirements	Requires various parameters of the motor	Requires RTT files, ANFYS model files and external models motor parameter info	Require RTT files and describe FEA model
Resources	Involves relatively smaller amount of calculations and requires less resources	Involves medium amount calculations and requires more resources than the constant parameter model	Involves heavy calculation and a more complex algorithms.
Fidelity	Lowest	Medium	Highest Simulation

The motor simulation model contains three different models, such as linear or constant, variable and finite model as shows in Table.-I. The RTT files can be download direct from website or create on JMAG-RT software.

The electrical torque of three phase alternating current induction motor as follows.

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)(\lambda_{s\alpha} I_{s\beta} - \lambda_{s\beta} I_{s\alpha}) \quad (1)$$

Where P is the number of poles.

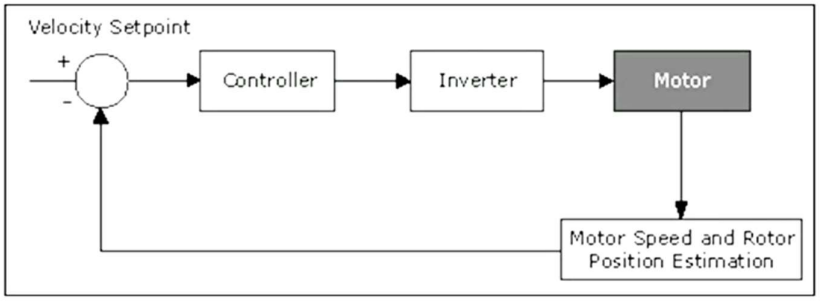

Fig.1 Closed loop motor model simulation block diagram

Fig.1. Shows the basic closed loop motor model of the system. The motor speed and rotor position sense using hall sensor and fed the information to the comparator. The comparator compare with velocity set-point. The comparator fed to the controller. Controller gives the commands to the inverter to operating switch. Followed by the inverter commands the motor rotates.

The motor model simulation concepts includes the Ansys motor model files, RTT file, and base value of the motor.

$$Per\ unit\ value\ = \frac{Real\ value\ (any\ unit}{Base\ value\ (\ same\ unit\ as\ real\ value)} \quad (2)$$

The basic three motors contains AC induction motor, PMSM, and SRM. The flow chart of these motor as follows. These motor simulate using three different ways one is constant parameter model, variable parameter model and FEA i.e finite define model. The FEA contains RTT file. Variable parameter requires ANSYS motor model file. The ANSYS similar to the text file. The Text file call inside the LabVIEW. The SRM contains two possibility one is Linear model and FEA. The ACIM perform on constant parameter model.

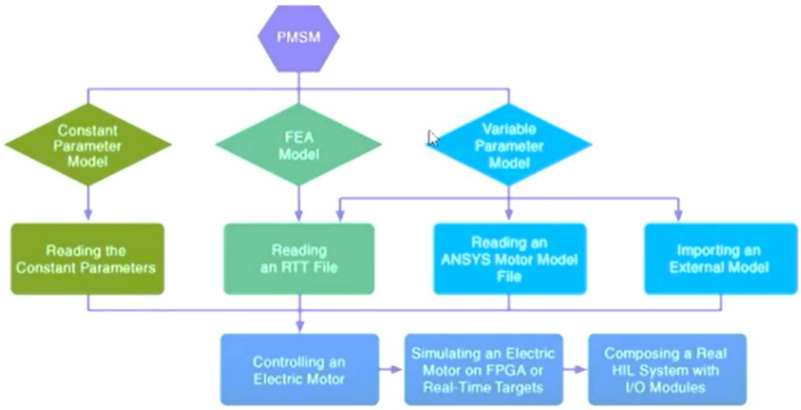

Fig.2 Simulation model of PMSM

Fig.2 shows the simulation model of the Permanent synchronous motor. It simulate on three possible methods such as constant, variable and Finite model. The linear model read the constant parameter and pass to the controlling on electrical motor, Based on the control information simulating the model and feed to the FPGA real time controller kit. The kit composing a real HIL system with input and output modules. The FEA read the RTT file and feed to the controller. If it perform on Vairalbe mode, it perform ANSYS motor model text file and feed to the controller.

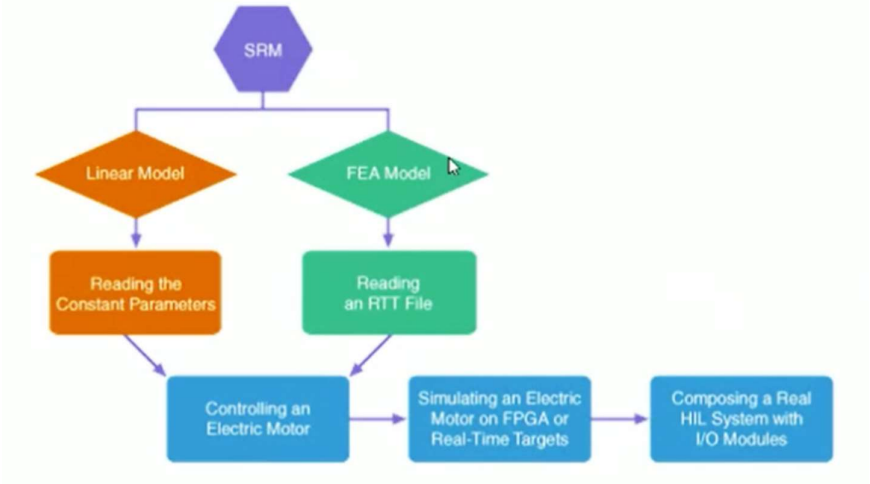

Fig.3 Simulation model of SRM

Fig.3 shows the simulation model of switched reluctance motor. The switched reluctance motor doesn't contains variable parameter model. It possibility to operate on linear model and FEA model. The linear model read the constant parameter and FEA model read an RTT file. These info feed to the controller followed by FPGA real time targets and HIL system Input and output modules.

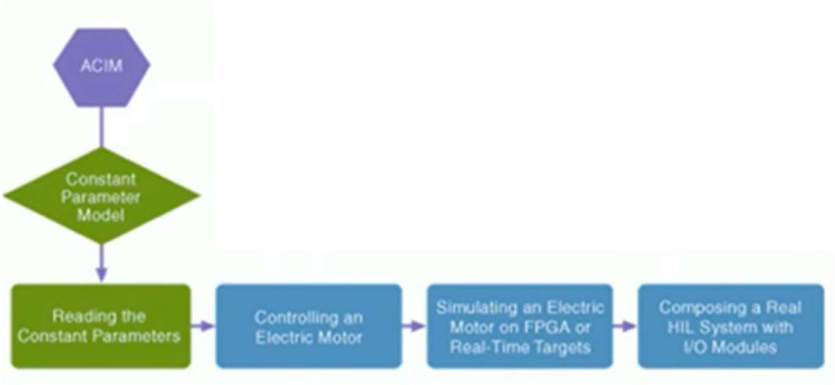

Fig.4 Simulation model of ACIM

Fig.4 shows the Alternating Current three phase induction motor. The ACIM operate only one constant parameter model and read the parameter feed to the controller. Followed by FPGA kit.

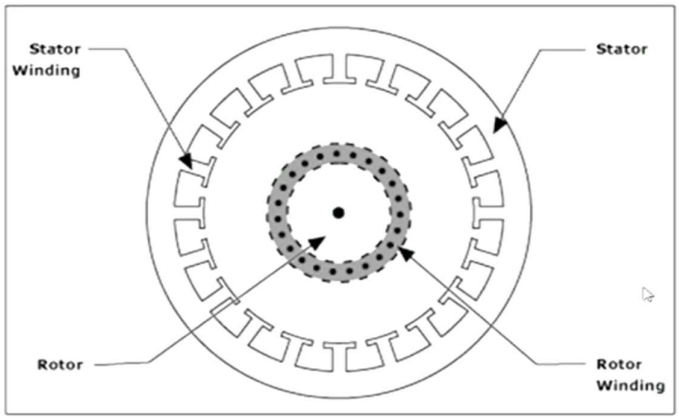

Fig.5 Model of three phase IM.

The three phase AC induction motor has only one is called constant parameter or linear model. It has stator and rotor. The angle reflection as shows in Fig.5. The stator is stationary winding and rotor has bar rod squirrel cage type of the construction. The constant parameter model as shown in Fig.6. It contains alpha and beta the beta is 90 degree from the alpha. The three windings of A, B, and C are 120 degree each other. The mathematical model developed from the constant parameter model

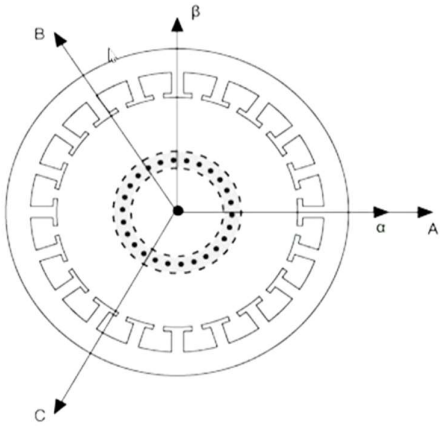

Fig.6 Constant Parameter model of ACIM

$$V_{s\alpha} = R_s I_{s\alpha} + \frac{d}{dt}\lambda_{s\alpha} \quad (3)$$

$$V_{s\beta} = R_s I_{s\beta} + \frac{d}{dt}\lambda_{s\beta} \quad (4)$$

$$V_{r\alpha} = R_r I_{r\alpha} + w_r \lambda_{r\beta} + \frac{d}{dt}\lambda_{r\alpha} = 0 \quad (5)$$

$$V_{r\beta} = R_r I_{r\beta} + w_r \lambda_{r\alpha} + \frac{d}{dt}\lambda_{r\beta} = 0 \quad (6)$$

The mathematical model developed from the constant parameter model of the three phase induction motor. Three phase current flows to the stator winding and produce magnetic field of RMF. The RMF generate the current in the rotor by faradays law of electromagnetic induction principle. Where R represented as Rotor. Rs is stator resistance. Similarly flux linkage equation of the AC induction motor as follows. The flux linkage derived from the constant parameter of above model equation.

$$\lambda_{s\alpha} = (L_{is} + L_m) I_{s\alpha} + L_m I_{r\alpha} \quad (7)$$

$$\lambda_{s\beta} = (L_{is} + L_m) I_{s\beta} + L_m I_{r\beta} \quad (8)$$

$$\lambda_{r\alpha} = (L_{ir} + L_m) I_{r\alpha} + L_m I_{s\alpha} \quad (9)$$

$$\lambda_{r\beta} = (L_{ir} + L_m) I_{r\beta} + L_m I_{s\beta} \quad (10)$$

Where Lis is stator leakage inductance, Lir – rotor leakage inductance. Lm- magnetizing inductance. Similarly current of alpha and beta using orthogonal coordinate system.

$$I_{s\alpha} = \frac{\lambda_{s\alpha} - \lambda_{m\alpha}}{L_{is}} \quad (11)$$

$$I_{s\beta} = \frac{\lambda_{s\beta} - \lambda_{m\beta}}{L_{is}} \quad (12)$$

$$I_{r\alpha} = \frac{\lambda_{r\alpha} - \lambda_{m\alpha}}{L_{ir}} \quad (13)$$

$$I_{r\beta} = \frac{\lambda_{r\beta} - \lambda_{m\beta}}{L_{ir}} \quad (14)$$

Fig.7 shows the PMSM constant parameter entry with define of speed 1800 Revolution Per Minute (RPM), samples 30,000 and time period $2x10^{-6}$, number of poles considered 4, Resistance 0.25 ohm, inductance 2.62 milli-Hendry and flux leakage 0.0271 wb. Fig.8 shows the ACIM parameter values of speed, samples, amplitude, stator leakage inductance, rotor leakage inductance, magnetizing inductance, number of poles, base temperature, stator and rotor temperature coefficient and stator and rotor temperature values.

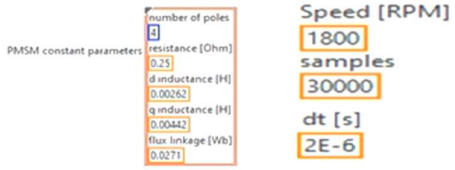

Fig.7 Constant parameter of PMSM model

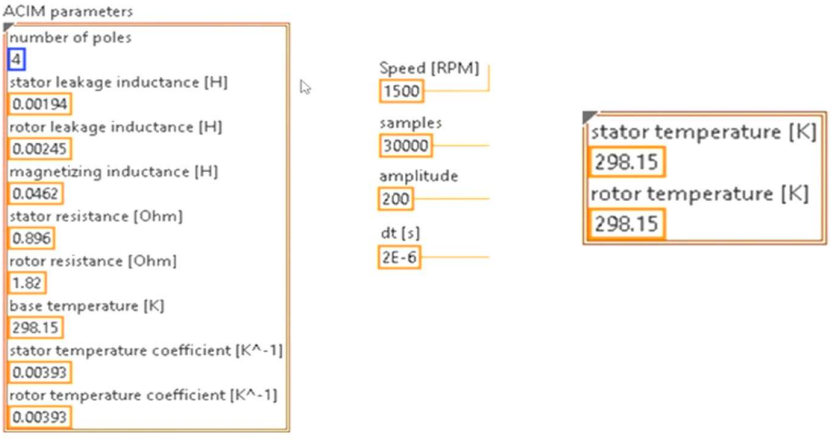

Fig.8 ACIM parameter model

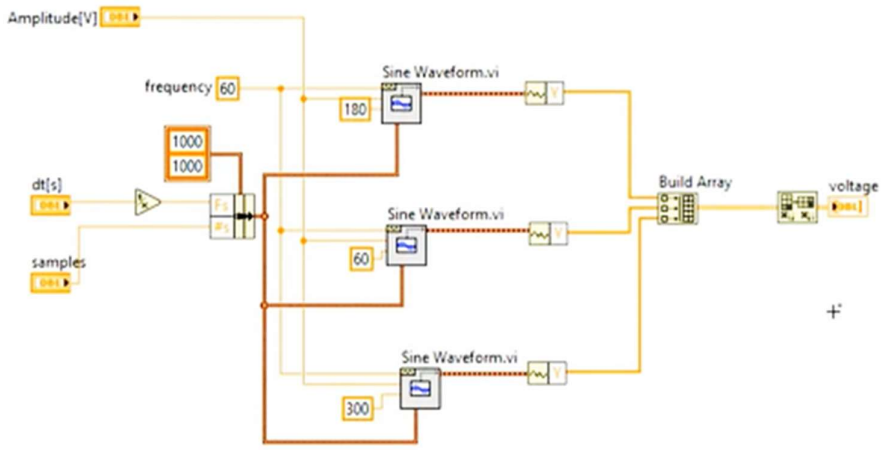

Fig.9 Three phase Sinusoidal waveform creation

Fig.9 Developed three phase sinusoidal waveform on LabVIEW. In the design 60Hz frequency was considered, amplitude, samples, dt as input of sine wave and angle difference between one phase to another phase was mentioned. The output of the sine waveforms of each combined with help of build array followed by produce the three phase output voltage.

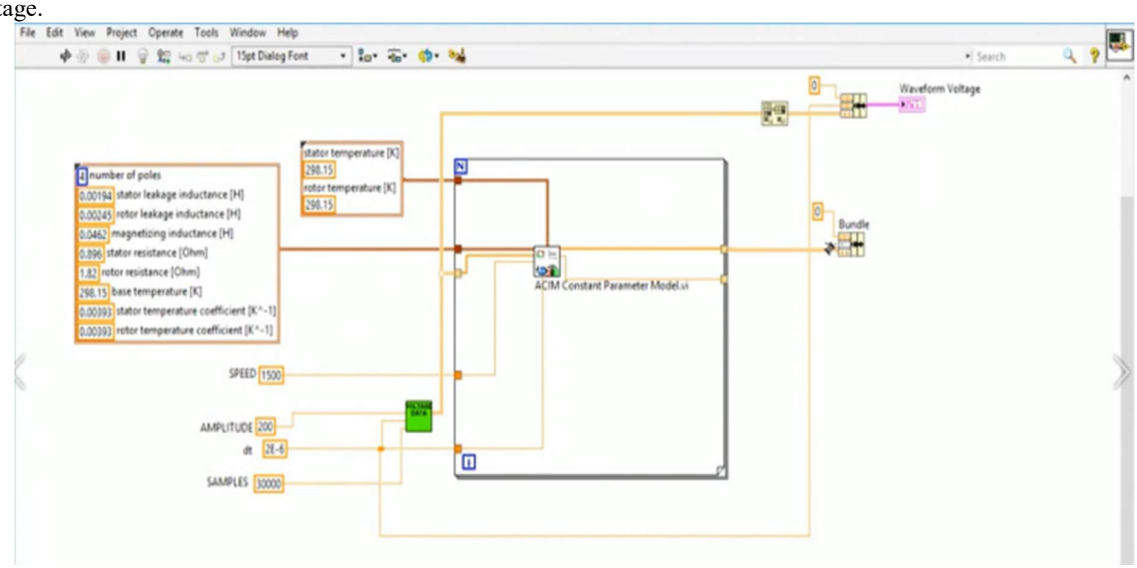

Fig.10 Proposed ACIM mathematical modelling on LabVIEW

Fig.10 shows the proposed AC IM mathematical modelling implemented on LabVIEW. The input of the ACIM contains Speed 1500 RPM, Amplitude of each phase =200 volts, change in time period $2x10^{-6}$, and samples of 30,000. Further stator and rotor temperature considered as 298.15K. In addition with define the number of poles, stator and rotor leakage inductance, magnetizing inductance, stator and rotor resistance value and temperature coefficient value. Fig.11 shows the three phase sinusoidal waveform, current waveform and torque of ACIM.

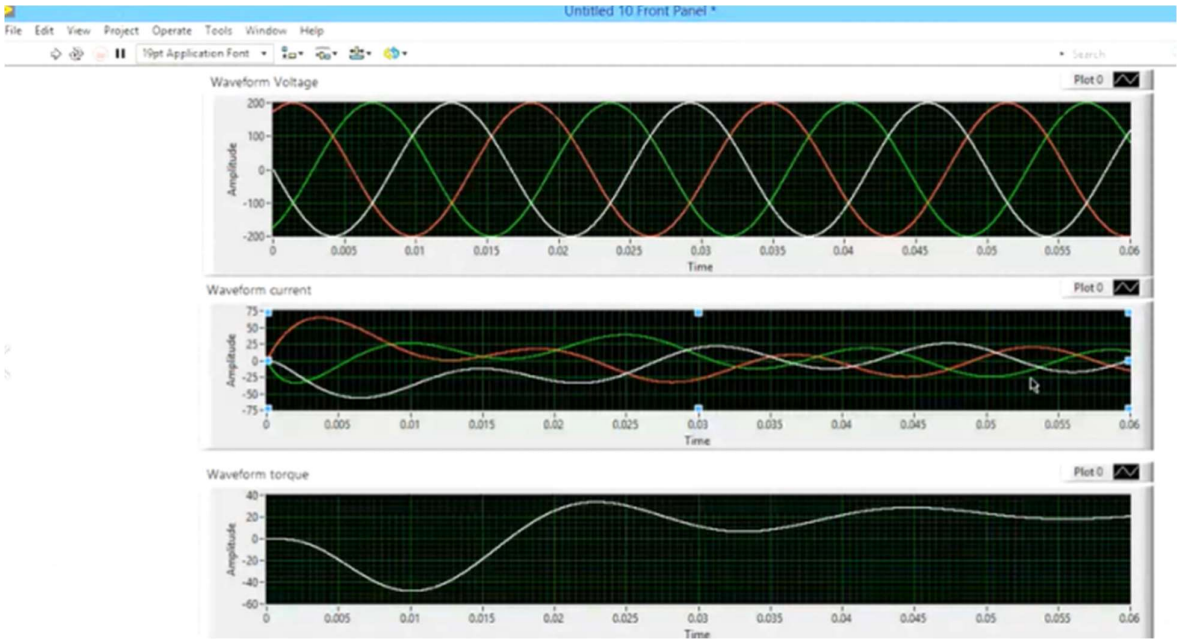

Fig.11 Results of the AC IM

3. CONCLUSION

This research article provides the modelling of ACIM for Electrical vehicle was developed using LabVIEW tool software. The article presents a mathematical ACIM equation on LabVIEW for review the outcomes of the ACIM in terms of output current and torque of the motor. The simulation design of the various electrical vehicle drives was addressed here. Moreover, a complete mathematical model is formulated ACIM. To validate the robustness of the proposed system, vary the inputs parameter of the proposed system. The inputs of the ACIM includes speed, amplitude of each phase voltage, change in time period, and samples. The outcomes of the results is highly efficient and extension for hardware implementation and testing of electrical vehicle drives.

REFERENCES

[1] F.Z. Pneg, "Z source inverter", Conference Record of the 2002 IEEE Industry Applications Conference. 37th IAS Annual Meeting , 13-18 October, 2022

[2] R.Arulmurugan, "A Simulation Analysis of a PV-Powered Inc-Cond MPPT-Based Hybrid Filter for Power Quality Improvement", International Journal of Social Ecology and Sustainable Development, Volume 13, Issue 1, pages: 1-16, 2022 DOI: 10.4018/IJSESD.293249 https://www.igi-global.com/article/a-simulation-analysis-of-a-pv-powered-inc-cond-mppt-based-hybrid-filter-for-power-quality-improvement/293249

[3] Chandramouli A, Arulmurugan, R and Sivachidambaranathan, "Review of performance Improvement of VSS FLC and MPPT photovoltaic power system", Ebook: Intelligent Systems and Computer Technology, Series:Advances in Parallel Computing, Vol.37, 2020, pp-84-89 doi:10.3233/APC200123 [Scopus), ISBN978-1-64368-102-3 (print) | 978-1-64368-103-0 (online) http://ebooks.iospress.nl/volume/intelligent-systems-and-computer-technology

[4] Dr.R.Arulmurugan, Mr.A.Chandramouli , "Modeling of PV powered seven-level Inverter for power quality improvement", 2nd International Conference on Smart Computing & Informatics (SCI-2018), Siddhartha Institute of Technology, Vijayawada, Andhra Pradesh, India 27-28 January, 2018 DOI: 10.1007/978-981-13-1927-3_12 https://link.springer.com/chapter/10.1007/978-981-13-1927-3_12

[5] Manik T. Shinde, R.Arulmurugan, Sachin V. Chaudhari, Prashant V. Thokal, "Study of Hybrid wind-solar Green Energy System"in the ", Test Engineering and Management journal, March - April 2020 ISSN: 0193-4120 Page No. 2010 – 2017 http://testmagzine.biz/index.php/testmagzine/article/view/3921

[6] Prashant .V. Thokal, R.Arulmurugan, Manik T. Shinde, Sachin V. Chaudhari, "Hybrid peddle and solar electric vehicle for physically challenged people", Test Engineering and Management journal, March - April 2020 ISSN: 0193-4120 Page No. 2037 - 2042 http://testmagzine.biz/index.php/testmagzine/article/view/3925

[7] A.Chandramouli, V.Svachidambaranatham and R. Arulmurugan, "Modelling and Design of Five Parameter Single Diode Photovoltaic Model with Artificial Intelligent MPPT Power System", International Journal of Recent Technology and Engineering (IJRTE), Volume-8 Issue-2S8, August 2019 pp.1063-1068 DOI:10.35940/ijrte.B1014.0882S819 https://www.ijrte.org/wp-content/uploads/papers/v8i2S8/B10140882S819.pdf

[8] G.Ramanathan, C.Bharatiraja, R.Saketh Srikar, D.Surya Tej, "Implementation of modified Z-source inverter integrated for electric vehicle fast charging ", materialstoday proceeding, vol.65, part.1, pp.265-270, 2022

[9] Dr. R. Rajendran, R. Sathiyavani, R. Balakrishnan, Dr. R. Arulmurugan, "An Overview of Microprocessor control of Inverter", International Journal of Engineering & Technology,vol. 7 (3.24), PP.532-535, 2018 http://dx.doi.org/10.14419/ijet.v7i3.24.22808 ISSN: 2227-524X

[10] Dr. R. Arulmurugan, Dr. B. Rajender, B. Sathyavani, K. Balakrishna, "An Overview of Converters and Inverters", International Journal of Engineering & Technology-UAE, Vol. 7, issue.3.34,2018, PP-992-994 ISSN:2227-524X. https://www.sciencepubco.com/index.php/ijet/article/view/25348/12914

[11] B. Sathyavani, K. Balakrishna, Dr. R. Arulmurugan, Dr. B. Rajender , "Highly Efficient and Reliable Inverter Concept topology with Matlab Simulation towards the Safety Requirement of Leakage Currents", International Journal of Engineering & Technology-UAE , Vol.7, issue.3.34, PP.998-1000 2018, ISSN:2227-524X. https://www.sciencepubco.com/index.php/ijet/article/view/25350/12916

[12] Dr. R. Arulmurugan, "Photovoltaic powered transformer less hybrid converter with active filter for harmonic and reactive power compensation", ECTI Transactions on Electrical Engineering, Electronics, and Communications, Vol.16, No.2, PP.44-51, August 2018 ISSN: 1685-9545 https://ecti-eec.org/index.php/ecti-eec/article/viewFile/540/204

[13] Muhammad H. Rashid, 1993. Power Electronics Circuits Devices and Applications. 2nd Edn. Englewood Cliffs, N.J., Prentice Hall.

[14] Arulmurugan R, Monika P, "A simulation analysis of PV powered Inc-Cond MPPT based transformerless hybrid active filter for power quality improvement", IJRA, Vol. 6, No. 4, December 2017. Issn:2089-4856 DOI: http://doi.org/10.11591/ijra.v6i4.11510 http://iaescore.com/journals/index.php/IJRA/article/view/11510

[15] Arulmurugan, R, "Comparative evaluation of new FLC controller based MPPT for a DC to DC buck-boost zeta converter" WSEAS Transactions on power systems, vol.11, pp.27-34, 2016, E-ISSN: 2224-350X

[16] Jaiswal, S. P., Bhadoria, V. S., Singh, R., Shrivastava, V., & Ambikapathy, A. Case Study on Modernization of a Micro-Grid and Its Performance Analysis Employing Solar PV Units. In Energy Harvesting (pp. 81-104). Chapman and Hall/CRC, 2020.

[17] Yadav, D., Singh, N., & Bhadoria, V. S. "Comparison of MPPT Algorithms in Stand-Alone Photovoltaic (PV) System" on Resistive Load. In Machine Intelligence and Smart System (pp. 385-400). Springer, Singapore, 2021.

[18] Yadav, R. K., Bhadoria, V. S., & Hrisheekesha, P. N. (2019, October). Technical and Financial Assessment of a Grid Connected Solar PV Net Metering System for Residential Community. In 2019 2nd International Conference on Power Energy, Environment and Intelligent Control (PEEIC) (pp. 299-303). IEEE.

[19] Paliwal, S., Bhadoria, V. S., & Sharma, P. "Renewable Energy Potential Assessment in Indian Perspective", International Journal of Engineering Research and Technology, 6(6), 801-810, 2013.

[20] Sambhi, S., Sharma, H., Bhadoria, V., Kumar, P., Chaurasia, R., Chaurasia, G. S and Pavlatos, C. "Economic Feasibility of a Renewable Integrated Hybrid Power Generation System for a Rural Village of Ladakh. Energies", Vol.15, Issue.23, PP-91-26, 2022.