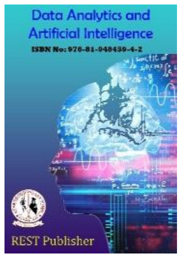
Data Analytics and Artificial Intelligence
Vol: 3(6), 2023
REST Publisher; ISBN: 978-81-948459-4-2
Website: http://restpublisher.com/book-series/daai/



A Data Driven Fault Diagnosis in Drive of Electric Vehicle

Dhanu Sree .M, Smitha.S
Ponjesly College of Engineering, Nagercoil, India,
Corresponding author: dhanumsree19@gmail.com

Abstract: *A vital component of battery electric vehicles is the electric propulsion system (BEVs).Performance degradation in the drive system may result from anomalies in the electric drive system components and, more seriously, a loss of power in the vehicle. Hence, an integrated prognosis system is proposed for the early isolation and identification of failures in the electric drive system and its components. By tracking the performance of the various health indicators, an integrated prognostic and fault isolation technique is employed to identify the primary source of electric drive faults based on the on board sensors. The fault detection and isolation (FDI) method is developed here based on the theoretical foundations of electric drives to simulate the normal condition The prognostic system employs a hierarchical approach: it first determines whether there has been a degradation in the electric drive system by comparing the system achieved torque with the estimated torque, and then checks multiple component-level health indicators for the various components making up an electric drive system, including three phase current sensors and short circuits. The prognosis system sends out an alert when a component is found to be degrading to a specific degree before the drive system experiences a major performance reduction, sparing the customers from a situation where they lose propulsion and have to walk home.*

Keywords: *Prognosis, early detection, fault isolation, electric drive system, health indicators.*

1. INTRODUCTION

The necessity for better fuel economy and the increasingly strict government regulations for CO2 emissions which made electrification a trend and becomes one of the major plans for the future of the vehicle industry. One of the key components of the power train for electric and hybrid vehicles (EVs/HEVs) is the electric drive system. The electric drive system for battery electric vehicles (BEVs) is a single point of failure. Electric drive failure detection techniques can generally be classified into two approaches : data-driven approaches and model-based approaches. Spectrum analysis-based data driven techniques are effective at spotting internal imbalances caused by mechanical or electrical issues in an drive system. Model-based approaches demand a prior understanding of the system dynamics by analysing the well-known mathematical models representing the system. A permanent magnet synchronous machine (PMSM), a motor controller, and a three-phase inverter make up a BEV's electric drive system. The PMSM and motor controller maintain the electric motor's torque output at the desired level. The switching commands regulate the on/off states of these power switches. In order for the electric motor to produce the correct torque, the output voltages of the inverter are properly adjusted to the appropriate values.

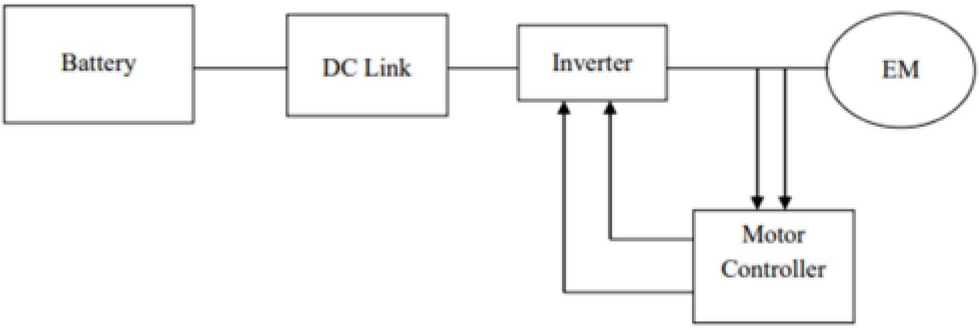


FIGURE 1. Block diagram of fault detection and isolation method

The power for the electric motor PMSM is converted from the DC Battery to AC via DC to DC converter and Inverter. As the accelerator is pressed, a signal is sent to the controller. The Controller adjusts the speed of the vehicle by changing the frequency of the AC power from the inverter to the motor. With the controller set, the inverter then sends a certain amount of electrical energy to the motor. Electric motor converts electrical energy into mechanical energy. Rotation of the motor rotor rotates the transmission so the wheels turn and then the car moves. If the 0 are pressed, or the electric car is decelerating, the motor becomes an alternator and produces power, which

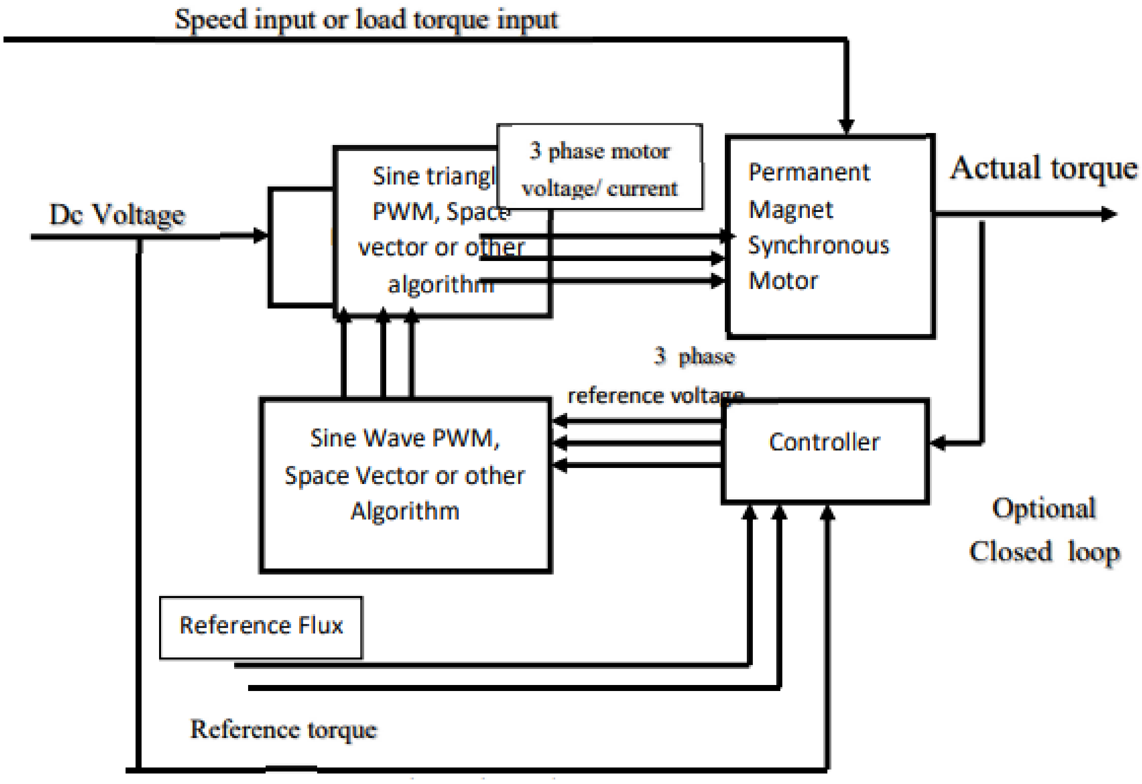


FIGURE 2.

Here the controller compares the reference torque with the actual torque and determines the fault detection with the changes in the error value obtained by comparison. Here we use the SVPWM inverter which is usually based on fault oriented control.

2. PROGNOSTIC FRAMEWORK

The prognostic framework for electric drive system, there are two major steps in this framework: Calculation of health indicators from the signals of interest, including existing sensor¬ measurements or controller inputs Prognostic algorithm for decision making and generate prognostic results.¬ The measured three phase currents and motor position, measured DC voltage and DC current, as well as reference voltages in dq reference frame from the motor controller, are the signals of interest for the electric drive system.

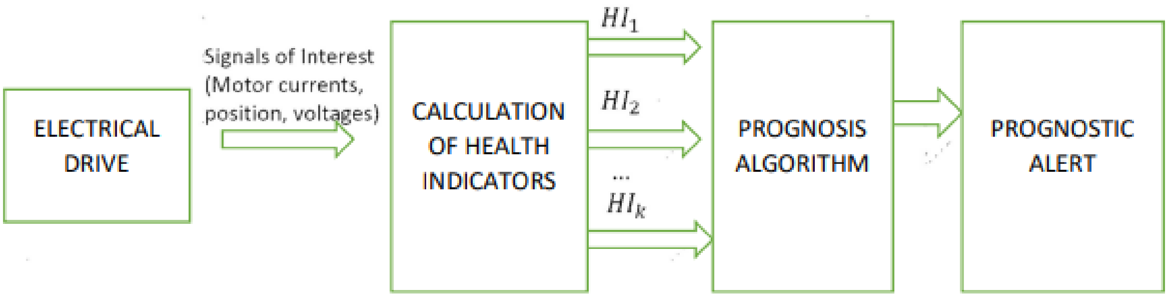


FIGURE 3. Prognosis Algorithm

The prognostic algorithm created in this paper takes a hierarchical approach: initially it looks at the system level health indicator to see if there is performance degradation in the overall electric drive system, and if there is a decrement , the algorithm then goes on to look at the individual components of the electric drive system.to identify the problematic component, dig deeper to the lower level health indicators.

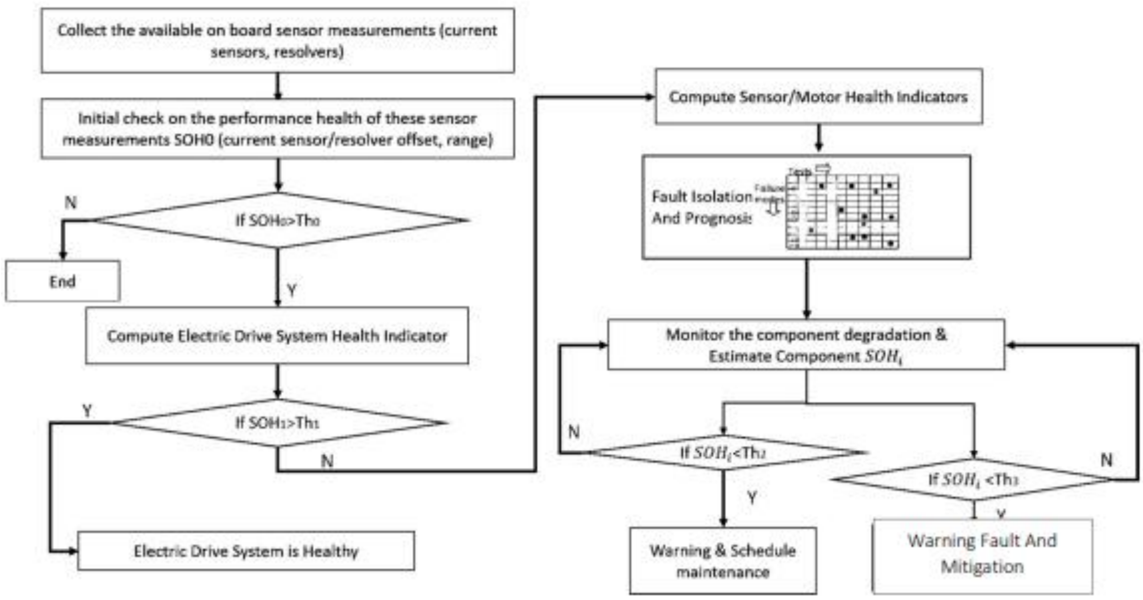


FIGURE 4. Flow Chart of Prognosis Algorithm

The hierarchical prognostic algorithm proposed in this paper. After we collect the onboard sensor signals, we perform an initial check on the sensor range/performance. If there are any out-of-range faults in the current sensors/resolver, the diagnostics would be triggered, and the rest of the process would not proceed. On the other hand, if the performance of the sensors is within the pre-defined threshold (Th0), then the prognostic system will first perform the electric drive health check by checking the performance of the electric drive system level health indicator. If the State of Health (SOH) of the electric drive is above a certain threshold (Th1). Otherwise, the algorithm proceeds to the component level prognosis.

Advantages: Highly accurate, Can predict the drive system Components also, and High Performance Ratio

2. RESULTS AND DISCUSSIONS

Simulation Results For DC Power Measurement:

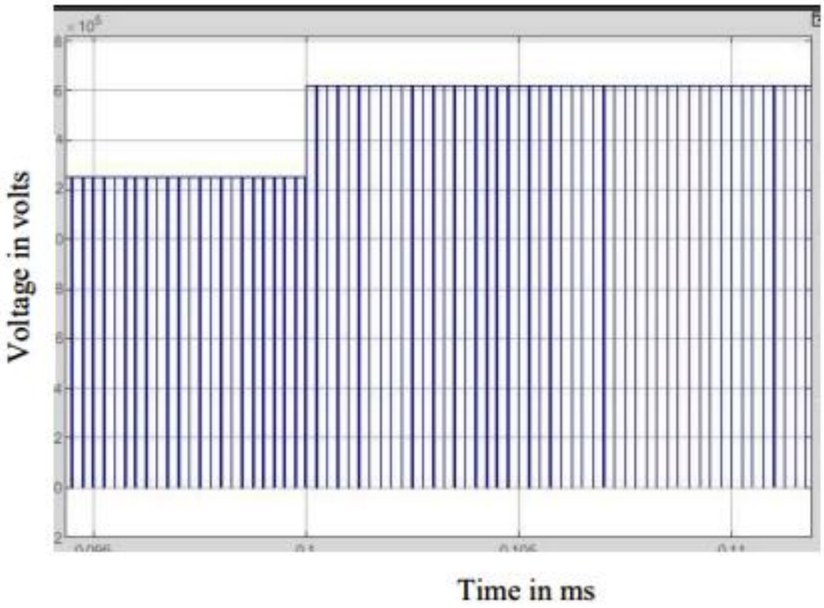


FIGURE 5. Simulation Results for DC Power Measurement

The above simulation diagram shows that the results for the DC power measurement. Here X axis denotes the time scale based on frequency value and Y denotes the voltage level based on amplitude. DC Power Measurement the value can be generated above the zero range.

Simulation Results for Inverter Power Loss:

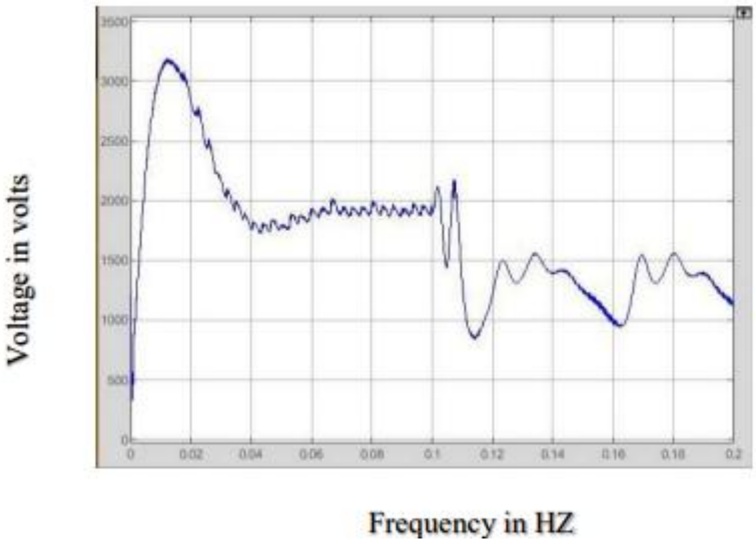


FIGURE 6. Simulation Results for Inverter Power Loss

The above simulation diagram shows that the results for the inverter power loss measurement. Here X axis denotes the time scale based on frequency value and Y denotes the voltage level based on amplitude. Inverter power loss measurement the voltage and current value can be varied with respect to the varying motor.

Simulation Results for No Fault:

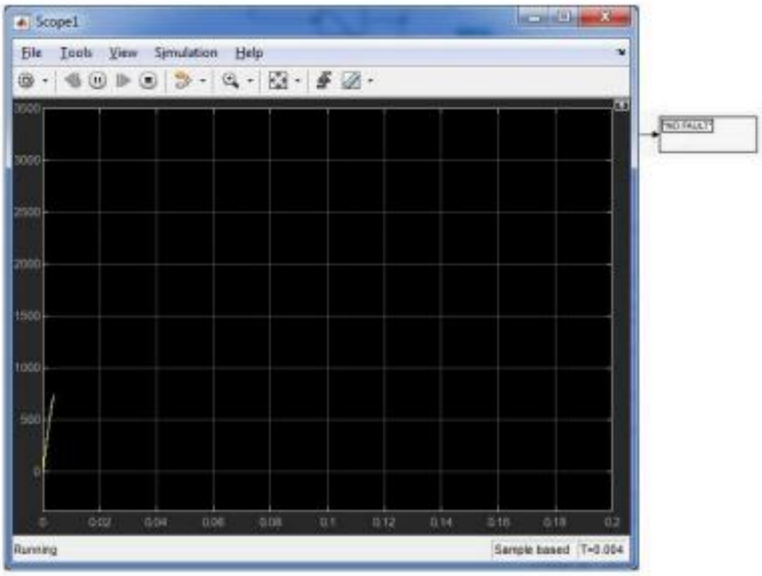


FIGURE 7. Simulation Results for No Fault

The above simulation diagram shows that the results for no fault. In electric drive system initially the motor can be run based on the load condition. So that the drive system can safe as 'No Fault' indication.

Simulation Results for Short Circuit:

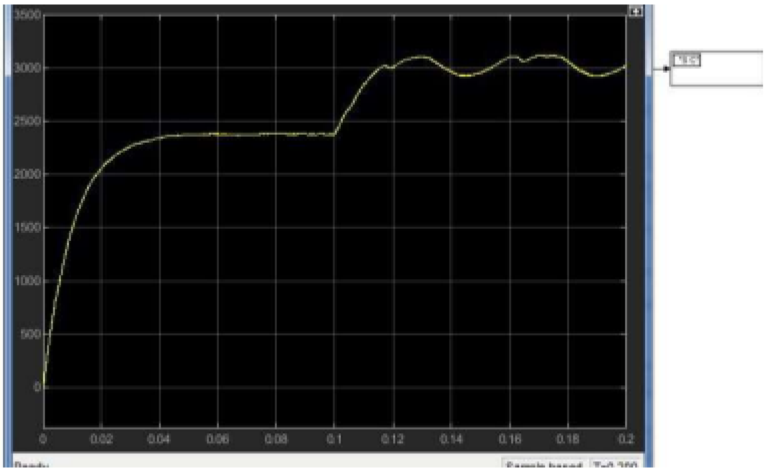


FIGURE 8. Simulation Results for Short Circuit

The above simulation diagram shows that the results for short circuit. As the electric drive system faults are considering is at a very early stage, way before the drive system gets short circuited, under which circumstance the motor performance is barely affected.

5. CONCLUSION

An integrated fault isolation and prognosis system for the essential elements of an electric drive is presented in this study. The prognosis system collects data from the resolver, three phase current sensors, and reference voltage control inputs. By comparing the estimated torque based on the DC input power and power losses with the calculated achievable torque based on motor currents, it first determines whether the drive system's performance has degraded. If there has been a performance decline, the process then moves on to identifying the error's primary cause, which is either a motor problem. or a sensor fault . The performance of the health indicators and the prognosis algorithm is validated both on a motor dyno and a vehicle dyno, where a production drive motor is used. The findings demonstrate that the prognosis system is effective in isolating component faults and forecasting drive system performance degradation, which can shield consumers from circumstances in which they lose propulsion and must walk home.

Future Scope: Moreover to improve the electric drive system as to add the renewable generation source as photovoltaic installation and the battery control process which are add to improve the overall system performance.

REFERENCES

[1]. Cai.B, Y. Zhao, H. Liu .and M. Xie. (2016) ‘A data-driven fault diagnosis methodology in three-phase inverters for PMSM drive systems,’ IEEE Transactions on Power Electronics, Vol. 32, No. 7, pp. 5590–5600.

[2]. Cruz S.M, and A. M. Cardoso. (2001)’Stator winding fault diagnosis in three phase synchronous and asynchronous motors, by the extended park’s vector approach,’ IEEE Transactions on industry applications, Vol. 37, No. 5, pp. 1227–1233.

[3]. Grouz.F , L. Sbita. and M. Boussak . (2013) ‘Current sensors gain faults detection and isolation based on an adaptive observer for PMSM drives,’ in 10th International MultiConferences on Systems, Signals & Devices (SSD13). IEEE, 2013, pp. 1–6.

[4]. Hong.J, S. Park, D. Hyun .and A. Haumer. (2012) ‘Detection and classification of rotor demagnetization and eccentricity faults for pm synchronous motors,’IEEE Transactions on Industry Applications, Vol. 48, No. 3, pp. 923– 932.

[5]. Jun E.S, S.-y. Park . and S. Kwak. (2019) ‘A comprehensive double-vector approach to alleviate common-mode voltage in three-phase voltage source inverters with a predictive control algorithm,’ Electronics, vol. 8, no. 8, p. 872, 38

[6]. Krause.P, O. Wasynczuk. and S. D. Pekarek. (2012) ‘Electromechanical motion devices’ John Wiley & Sons, , Vol. 90.

[7]. Lee.J, Y.-J. Jeon, D.-c. Choi, S. Kim. and S. W. Kim. (2013) ‘Demagnetization fault diagnosis method for PMSM of electric vehicle,’ in IECON 2013- 39th Annual Conference of the IEEE Industrial Electronics Society. IEEE , pp. 2709– 2713.

[8]. Li.B, M.-Y. Chow, Y. Tipsuwan . and J. C. Hung. (2000) ‘Neural-network based motor rolling bearing fault diagnosis,’ IEEE transactions on industrial electronics, Vol. 47, No. 5, pp. 1060–1069

[9]. Meinguet.F, P. Sandulescu, X. Kestelyn .and .E. Semail, (2012) ‘A method for fault detection and isolation based on the processing of multiple diagnostic indices: application to inverter faults in ac drives,’ IEEE transactions on vehicular technology, Vol. 62, No. 3, pp. 995–1009.

[10]. Khan M.A.S and M. A. Rahman. (2008) ‘Development and implementation of a novel fault diagnostic and protection technique for ipm motor drives,’ IEEE Transactions on Industrial Electronics, Vol. 56, No. 1, pp. 85–92.

[11]. Mazzoleţ M.A, C. H. De Angelo .and D. R. EspinozaTrejo. (2017) ‘A model based strategy for interturn short-circuit fault diagnosis in pmsm,’ IEEE Transactions on Industrial Electronics, Vol. 64, No. 9, pp. 7218–7228 39.

[12]. Moon.S, H. Lee. and S. W. Kim. (2017) ‘Interturn short fault diagnosis in a PMSM by voltage and current residual analysis with the faulty winding model,’IEEE Transactions on Energy Conversion, Vol. 33, No. 1, pp. 190–198.

[13]. Murphey Y.L, M. A. Masrur, Z. Chen. and B. Zhang. (2006.) ‘Model-based fault diagnosis in electric drives using machine learning,’ IEEE/ASME Transactions On Mechatronics, Vol. 11, No. 3, pp. 290–303.

[14]. Najafabadi T.A, F. R. Salmasi. and P. Jabehdar-Maralani. (2010), ‘Detection and isolation of speed-, dc-link voltage-, and current-sensor faults based on an adaptive observer in induction-motor drives,’ IEEE Transactions on Industrial Electronics, Vol. 58, No. 5, pp. 1662–1672.

[15]. Nandi.S, H. A. Toliyat. and X. Li. (2005) “Condition monitoring and fault diagnosis of electrical motors—a review,’ IEEE transactions on energy conversion, Vol. 20, No. 4, pp. 719–729.

[16]. Schemmel.F, K. Bauer . and M. Kaufhold. (2009) ‘Reliability and statistical lifetimeprognosis of motor winding insulation in low-voltage power drive systems,’ IEEE Electrical Insulation Magazine, Vol. 25, No. 4, pp. 6–13

[17]. SchoenR.R , T. G. Habetler. and R. Bartfield. (1995) ‘Motor bearing damage detection using stator current monitoring,’ IEEE transactions on industry applications, Vol. 31, No. 6, pp. 1274–1279 .

[18]. Stack J.R, T. G. Habetler. and R. G. Harley. (2004) 'Fault classification and fault signature production for rolling element bearings in electric machines,' IEEE Transactions on Industry Applications, Vol. 40, No. 3, pp. 735–739. 40.
[19]. Rosero.J, J. Cusido. and L. Romeral. (2006) 'Broken bearings and eccentricity fault detection for a permanent magnet synchronous motor,' in IECON 2006- 32nd Annual Conference on IEEE Industrial Electronics. IEEE, 2, pp. 964–969.
[20]. Rothenhagen .K .and F. W. Fuchs. (2005) 'Performance of diagnosis methods for igbt open circuit faults in three phase voltage source inverters for ac variable speed drives,' in 2005 European Conference on Power Electronics and Applications. IEEE, Vol 10–pp.