ISSN: 2278-4632
Vol-11 Issue-01 2021

# AN ADVANCED FLC BASED BIDIRECTIONAL ELECTRIC-DRIVE SYSTEM FED WITH AN ELECTRIC VEHICLES

**JONNALAGADDA RAJA BABU [1], CH.VIJAY CHANDAR [2],T.RUSHI SANTOSH [3]**

[1]Student, M.Tech (PE&D), MVR COLLEGE OF ENGINEERING & TECHNOLOGY, A.P., India.

[2]Assistant Professor, Dept. of Electrical & Electronics Engineering , MVR COLLEGE OF ENGINEERING & TECHNOLOGY, A.P., India.

[3]Associate Professor and Head, Dept. of Electrical & Electronics Engineering , MVR COLLEGE OF ENGINEERING & TECHNOLOGY, A.P., India.

***Abstract—*** In this paper, an Electric-drive-reconstructed onboard converter (EDROC) based on a switching network in the DC side is proposed. The system can utilize the existing hardware of electric vehicles and does not need extra equipment. When the EDROC connects to the power grid through the power outlet at the office or home, there is not any additional equipment (filter or relay) on the AC side. Compare with traditional EDROC, the proposed novel EDROC has advantages in cost and volume. The EDROC can realize the unity power factor in the charging mode and discharges to drive the motor in the driving mode. A proof-of-concept prototype has been built to verify the charging function and driving function of the proposed EDROC.

**Keywords** Electric-drive-reconstructed onboard converter (EDROC) , ELECTRIC VEHICLES **,** power factor in the charging mode and discharges

## INTRODUCTION

The electrical drive system and charging system in PEV will replace the conventional drive system of the internal combustion engine (ICE) because the electric drive can achieve zero emissions [2]–[4]. Usually, the PEV is consisted of the charging system and the drive system, independently. The charging system is an important part of the electric drive, which contains two stages bi-directional converters [5], [6]. The drive system contains motor and driver circuit. The system has large size and high cost. The electric-drive-reconstructed onboard converter (EDROC) has been proposed to reduce the size and increase the power density by integrating the drive system and charging system in PEV [7]. So the converter can operate in drive mode or charging mode, independently. Meanwhile, the EDROC can be classified as three types based on the number of converters [8]: the composite converter system, the double-stage converter system, and the single-stage

ISSN: 2278-4632
Vol-11 Issue-01 2021

converter system. There are multiple motors and multiple power converters in the composite converter system, and the system is often applied to the four-wheel-drive EV or a series hybrid electric vehicle [9], [10]; Composite converter system is not suitable for a single-motor EV such as PEV. Owing to only one motor is needed, the double-stage converter system and the single-stage converter system can be applied to most types of electric vehicles. The double-stage converter system is usually applied to three-phase fast charging. It has more components than the single-stage converter system, so the single-stage converter system has advantages in terms of cost and size. Generally, the EDROC uses the motor windings as inductors in the charging mode. However, the conventional motor in PEV is the permanent magnet synchronous motor(PMSM) [11], [12], which is not conducive to reconfiguring the converter as a charger. Some specially designed motors are used as charger in [14]–[20]. The EDROC with a split-winding AC motor has been proposed in [14]–[16]. In the charging mode, the motor winding and 3 H-bridge inverters are reconfigured as two 3-phase boost converters sharing a DC bus. The AC power supply connected to the middle point of the stator winding. This converter is complicated as it must control three independent currents in the driving mode. The motor with two sets of three-phase windings is used in [17], [18]. In the driving mode, the motor work as a three-phase motor; In the charging mode, the motor work as a transformer. The other EDROCs with specially designed motors are connected AC source to the neutral point of the motor in [19], [20]. However, the specially designed motors are more complicated than conventional traction motors, and additional terminals need insulation protection. Consider the conventional electric motor of PEV, the EDROC with AC additional equipment is proposed and studied in [21], [22]. The additional equipment can be onboard without especially insulation protection. However, the system adds an uncontrolled rectifier unit or relay, the additional equipment takes up extra space.

## LITERATURE SURVEY

In 1997 Jang-Mok, K. and Seung-Ki, S. [3], proposed a novel flux-weakening scheme for an Interior Permanent Magnet Synchronous Motor (IPMSM). It was implemented based on the output of the synchronous PI current regulator reference voltage to PWM inverter. The on-set of flux weakening and the level of the flux were adjusted inherently by the outer voltage regulation loop to prevent the saturation of the current regulator. Attractive features of this flux weakening scheme included no dependency on the machine parameters, the guarantee of current regulation at any operating condition, and smooth and fast

ISSN: 2278-4632
Vol-11 Issue-01 2021

transition into and out of the flux weakening mode. Experimental results at various operating conditions including the case of detuned parameters were presented to verify the feasibility of the proposed control scheme.

Bose, B. K., in 2001 [4], presented different types of synchronous motors andcompared them to induction motors. The modeling of PM motor was derived form the model of salient pole synchronous motor. All the equations were derived in synchronously rotating reference frame and was presented in the matrix form. The equivalent circuit was presented with damper windings and the permanent magnet was represented as a constant current source. Some discussions on vector control using voltage fed inverter were given.

Ong, C in 1998 [5], explained the need for powerful computation tools to solve complex models of motor drives. Among the different simulation tools available for dynamic simulation he had chosen MATLAB/SIMULINK® as the platform for his book because of the short learning curve required to start using it, its wide distribution, and its general purpose nature.

G. Venkaterama[6],; had developed a simulation for permanent magnet motors using Matlab/simulink. The motor was a 5 hp PM synchronous line start type. Its model included the damper windings required to start the motor and the mathematical model was derived in rotor reference frame. The simulation was presented with the plots of rotor currents, stator currents, speed and torque.

## MODELING OF PMSM

Detailed modeling of PM motor drive system is required for proper simulation of the system. The d-q model has been developed on rotor reference frame as shown in figure 3.1. At any time t, the rotating rotor d-axis makes and angle ¸r with the fixed stator phase axis and rotating stator mmf makes an angle ± with the rotor d-axis. Stator mmf rotates at the same speed as that of the rotor.

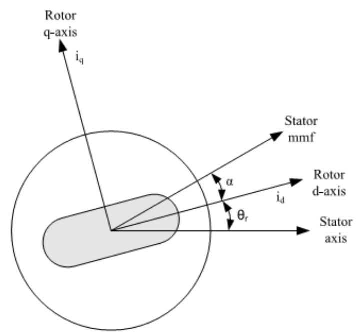



**Figure 3.1 motor axis**

The model of PMSM without damper winding has been developed on rotor reference frame using the following assumptions:

1) Saturation is neglected.

2) The induced EMF is sinusoidal.

3) Eddy currents and hysteresis losses are

ISSN: 2278-4632
Vol-11 Issue-01 2021

negligible

4) There are no field current dynamics

Voltage equations are given by:

$$V_q = R_s i_q + \omega_r \lambda_d + \rho \lambda_q$$

$$V_d = R_s i_d - \omega_r \lambda_q + \rho \lambda_d$$

Flux Linkages are given by

$$\lambda_q = L_q i_q$$

$$\lambda_d = L_d i_d + \lambda_f$$

Substituting equations 3.3 and 3.4 into 3.1 and 3.2

$$V_q = R_s i_q + \omega_r \left( L_d i_d + \lambda_f \right) + \rho L_q i_q$$

$$V_d = R_s i_d - \omega_r L_q i_q + \rho \left( L_d i_d + \lambda_f \right)$$

Arranging equations 3.5 and 3.6 in matrix form

$$\begin{pmatrix} V_q \\ V_d \end{pmatrix} = \begin{pmatrix} R_s + \rho L_q & \omega_r L_d \\ -\omega_r L_q & R_s + \rho L_d \end{pmatrix} \begin{pmatrix} i_q \\ i_d \end{pmatrix} + \begin{pmatrix} \omega_r \lambda_f \\ \rho \lambda_f \end{pmatrix}$$

The developed torque motor is being given by

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\left(\lambda_d i_q - \lambda_q i_d\right)$$

The mechanical torque equation is

$$T_e = T_L + B\omega_m + J\frac{d\omega_m}{dt}$$

Solving for the rotor mechanical speed from equation 3.9

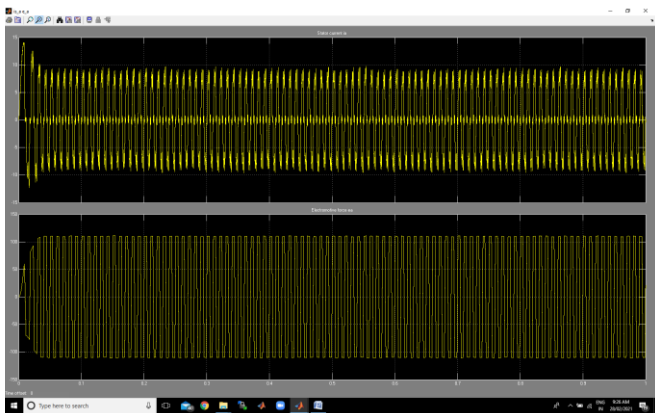
$$\omega_m = \int \left( \frac{T_e - T_L - B\omega_m}{J} \right) dt$$

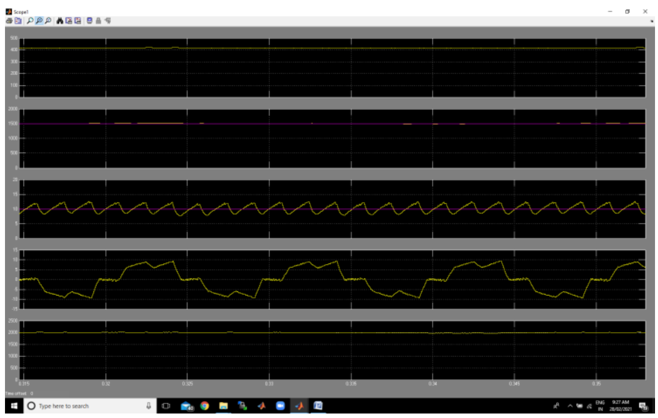
And

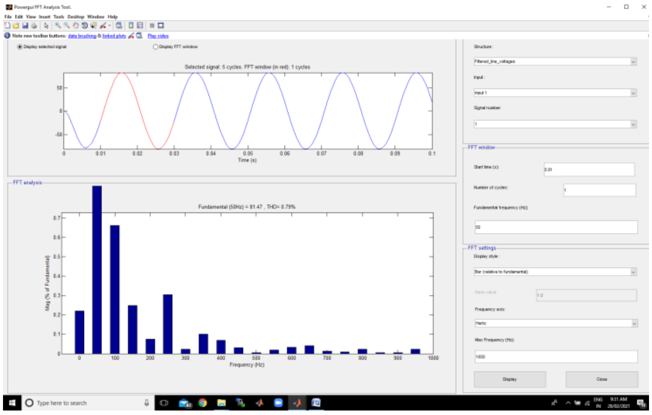
$$\omega_m = \omega_r \left( \frac{2}{P} \right)$$

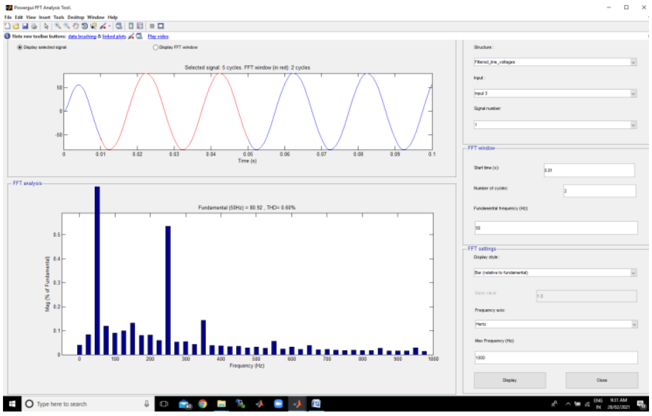
In the above equations ωr is the rotor electrical speed ωm is the rotor mechanical speed

## SIMULATION RESULTS









## CONCLUSION

In the paper, a novel and simple electric-drive reconstructed onboard converter is proposed. The proposed converter utilizes the conventional motor of PEV and is reconstructed by a switching network. The topology circuit of the proposed converter can be onboard without additional AC inductor. The proposed converter can directly utilize the socket power outlet at the office or home. The system can utilize the existing drive system without specially designed, and it has the advantages of simple structure and low cost. The performance of the propose EDROC is verified through simulation and experimental results.

## REFERENCES

[1] C. Chan, A. Bouscayrol, and K. Chen, ‘‘Electric, hybrid, and fuel-cell vehicles: Architectures and modeling,’’ IEEE Trans. Veh. Technol., vol. 59, no. 2, pp. 589–598, Feb. 2010.

[2] S. Kumar and A. Usman, ‘‘A review of converter topologies for battery charging applications in plug-in hybrid electric vehicles,’’ in Proc. IEEE Ind. Appl. Soc. Annu. Meeting (IAS), Portland, OR, USA, Sep. 2018, pp. 1–9.

[3] F. Berthold, A. Ravey, B. Blunier, D. Bouquain, S. Williamson, and A. Miraoui, ‘‘Design and development of a smart control strategy for plugin hybrid vehicles including vehicle-to-home functionality,’’ IEEE Trans. Transport. Electrific., vol. 1, no. 2, pp. 168–177, Aug. 2015.

[4] A. Rezaei, J. B. Burl, M. Rezaei, and B. Zhou, ‘‘Catch energy saving opportunity in charge-depletion mode, a real-time controller for plugin hybrid electric vehicles,’’ IEEE Trans. Veh. Technol., vol. 67, no. 11, pp. 11234–11237, Nov. 2018.

[5] F. Ahmadi, E. Adib, and M. Azari, ‘‘Soft switching bidirectional converter for reflex charger with minimum switches,’’ IEEE Trans. Ind. Electron., to be published.

[6] U. Yilmaz, O. Turksoy, and A. Teke, ‘‘Intelligent control of high energy efficient two-stage battery charger topology for electric vehicles,’’ Energy, vol. 186, Nov. 2019, Art. no. 115825.

[7] F. Yu, W. Zhang, Y. Shen, and J. Mao, ‘‘A nine-phase permanent magnet electric-drive-reconstructed onboard charger for electric vehicle,’’ IEEE Trans. Energy Convers., vol. 33, no. 4, pp. 2091–2101, Dec. 2018.

[8] M. Yilmaz and P. T. Krein, ‘‘Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles,’’ IEEE Trans. Power Electron., vol. 28, no. 5, pp. 2151–2169, May 2013.

[9] S. Haghbin, K. Khan, S. Lundmark, M. Alakla, O. Carlson, M. Leksell, and O. Wallmark, ‘‘Integrated chargers for EV’s and PHEV’s: Examples and new solutions,’’ in Proc. 19th Int. Conf. Elect. Mach.-ICEM, Sep. 2010, pp. 1–6.

[10] M. Grenier, T. Thiringer, and M. Aghdam, ‘‘Design of on-board charger for plug-in hybrid electric vehicle,’’ in Proc. 5th IET Int. Conf. Power Electron., Mach. Drives (PEMD), 2010, pp. 1–6.

[11] S. Morimoto, S. Ooi, Y. Inoue, and M. Sanada, ‘‘Experimental evaluation of a rare-Earth-free PMASynRM with ferrite magnets for automotive applications,’’ IEEE Trans. Ind. Electron., vol. 61, no. 10, pp. 5749–5756, Oct. 2014.

[12] A stepdown transformerless single stage single switch AC-DC converter.

[13] Co-ordinated control and energy management of distributed generation inverters in micro-grid.

[14] Energy management and power control of a hybrid active wind generator for distributed power generation and grid integration.

[15] Power quality improvement by generating multilevel current waveform.

[16] Grid connected PV system with hysteresis current controller based three-phase inverter fed induction motor drive applications.