PASSIVITY BASED CONTROL OF LUO CONVERTER

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Abstract— *In this paper trajectory tracking control of D.C. motor is achieved while requiring measurements of the Luo converter currents and voltage only. Exact Tracking Error Dynamics Passive Output Feedback (ETEDPOF) control technique is implemented in trajectory tracking control of D.C. motor The performance of ETEDPOF controller is verified through simulation experiment*.

Index Terms: DC motor, ETEDPOF, Luo converter, Trajectory tracking.

1. INTRODUCTION

Energy is one of the fundamental concepts in science and engineering practice, where it is common to view dynamical systems as energy-transformation devices [1]. This perspective is particularly useful in studying complex nonlinear systems by decomposing them into simpler subsystems that, upon interconnection, add up their energies to determine the behaviour of the full system. This "energy-shaping" approach is the essence of Passivity-Based Control (PBC) technique which is very well known in mechanical systems [2]. Passivity theory was initially proposed in circuit analysis. Passivity as a particular case of dissipativity was introduced by Willems and generalized by Hill and Moylan [18].

Passivity based controllers for power electronic circuits are usually synthesized with a stabilization objective in mind, i.e., to achieve a constant output voltage or a constant current in the circuit branches. In this context Euler Lagrange equations were used earlier for deriving PBC in various power electronic circuits, electrical machines and also in some mechanical systems [3]-[7]. Campos-Delgado *et al*. derived a unified frame work for the control of various DC motor configurations except PMDC motor [8]. In the reference [8] Passivity Based Control function was derived in such a way that the non linear terms in the torque equations are eliminated with the achievement of asymptotic velocity reference tracking. Hebertt Sira-Ramirez derived the switching function using PBC for boost-boost converter and three phase rectifier so that the tracking error can be stabilised to zero [9]. PBC technique can be implemented in various Power converters like Boost, Buck converter [9] - [10] and Multi level rectifiers [11]. In continuation of this Luo converter is selected for speed control of D.C. motor so that Buck Boost operation is possible with Luo converter.

Forouzantabar *et al.* proposed a passivity based architecture, which overcomes the conventional controllers in terms of position and force tracking in the control of bilateral tele operation systems with multi degrees of freedom [12].

Dynamic response, realization complexity and parameter sensitivity properties of single phase PWM Current Source Inverter are compared with Adaptive Digital Control, Sliding Mode Control and Passivity Based Control methods. The comparative result shows that dynamic response of PBC is better when compared with other controllers [13]. Linear average controller, Feedback linearizing controller, Passivity Based Controller, Sliding Mode Controller and Sliding mode plus Passivity Based Controller are implemented in Boost converter with Resistive load. The comparison is based on transient and steady state response to steps and sinusoidal output voltage references, attenuation of step and sinusoidal disturbances in the power supply and response to pulse changes in the output resistance [14]. The comparative result reveals that PBC achieved better disturbance attenuation.

In power flow control of Unified Power Flow Controller (UPFC), PBC dominates over PIC with respect to transient response with reduced oscillations in the real power [15]. Tzann-Shin Lee investigated the behavior of PBC + PIC and PIC in three phase AC/DC Voltage Source Converters and from the results, the author concluded that the performance of PBC with PIC is better than PIC [4].

Transient performances of PBC and PIC in H bridge resonant converter were compared by Y. Lu *et al.* [16] and the experimental results reveal that settling time and output voltage overshoot for PBC is lesser than PIC. A. Dell Aquila *et al.* proved that the stability properties of H bridge multi level converter with PBC is better than PIC [17]. Tofighi *et al.* achieved good tracking response, low overshoot and short settling time in photovoltaic system with PBC in comparison with PIC. The authors demonstrated the robustness of PBC in Photovoltaic Power Management system for the change in reference DC voltage, solar irradiance as well as load resistance [6].

The motivation for adopting the PBC approach in this paper is due to the following facts. Robustness in converters, synchronous motors, switched reluctance motors and bilateral teleoperation can be achieved using PBC [6], [19]-[21], [12]. Stability performance of PBC is promising in a variety of systems [21]-[32]. Due to this assurance in stability, PBC found applications in fuel cell, 1D piezoelectric Timoshenko beam, stochastic fuzzy neural networks [24]-[27], flight control design [33], Bidirectional Associative memory neural networks [34], Pose control, Continuous stirred Tank reactor and aircraft automatic landing systems [35] – [37]. PBC plays a vital role in A.C.-D.C. converters for the achievement of high power factor in comparison with Feed forward plus Non linear PIC [38], [39]. PBC can be used as a soft starter for DC motor and it can be implemented for speed control without any speed sensor [40], [41]. In traction applications, PBC achieves both stable operation and unity power factor [42]. With Interconnection and Damping Assignment PBC asymptotic stability can be realized [43], [44]. In synchronous reluctance motor drive systems PBC out performs PIC in various aspects such as transient response, load disturbance and tracking property [45].

From the above it is concluded that PBC can be used for many applications. The references [4], [6], [12] - [17], [38], [39], [45] confirm that PBC is better than other controllers.

Development of control functions using PBC is based mainly on Energy Shaping and Damping Injection (ESDI), Integral Damping Assignment PBC (IDA- PBC) and Exact Tracking Error Dynamics Passive Output Feedback (ETEDPOF) methods. The implementation of ETEDPOF method is not so exhaustive [9]-[10], [41], [46]- [50] when compared with ESDI methods [3]-[4], [6], [8], [11], [13]- [17], [20], [22], [26], [38], [40], [42], [45]- [46] and IDA-PBC. This has been the motivating factor for implementing ETEDPOF for Luo converter fed D.C. motor and to realize the benefits of the ETEDPOF which is presented in [10].

This paper is organised as follows: Modelling of Luo converter and D.C. motor is presented in Section 2. The Section 3 is devoted for the implementation of PBC. Section 4 describes the reference trajectory generation. To validate the ETEDPOF controller, Luo converter with DC motor set up is required, which is described in section 5. Simulation results are explained in section 5. The conclusions and the future scope for the work are given in section 6.

2. MODELLING OF Luo CONVERTER FED D.C. MOTOR

Closed loop operation of Luo converter fed separately excited D.C. motor is shown in Fig.1.With the available wide variety of pump circuits, fundamental positive output Luo converter was taken for the present work [49]. Using Kirchhoff's laws and Newton's laws; average model for Luo converter fed D.C motor can be derived. Due to the selection of armature control method for speed control, field circuit equations are omitted. The derived average model is given by

$$\frac{di_1}{dt} = \frac{uE}{L_1} - \frac{(1-u)}{L_1}v_1 \tag{1}$$

$$\frac{di_2}{dt} = \frac{uE}{L_2} + \frac{uv_1}{L_2} - \frac{v_2}{L_2} \tag{2}$$

$$\frac{dv_1}{dt} = \frac{(1-u)i_1}{C_1} - \frac{ui_2}{C_1} \tag{3}$$

$$\frac{dv_2}{dt} = \frac{i_2}{C_2} - \frac{v_2}{R_1 C_2} - \frac{i_m}{C_2} \tag{4}$$

$$\frac{di_m}{dt} = \frac{v_2}{L_m} - \frac{R_m}{L_m}i_m - \frac{K}{L_m}\omega \tag{5}$$

$$\frac{d\omega}{dt} = \frac{K}{J}i_m - \frac{B}{J}\omega - \frac{T_L}{J} \tag{6}$$

where

i_1	Inductor (L_1) current
i_2	Inductor (L_2) current
v_1	Capacitor (C_1) Voltage
v_2	Capacitor (C_2) Voltage
i_m	Motor armature current
ω	Angular velocity of the motor shaft$\left(\frac{2\pi N}{60}\right)$
k	EMF constant
R_m	Motor armature resistance
R_1	Load resistance
L_m	Motor armature inductance
L_{fm}	Motor field Inductance
u	Average control input
N	Speed of the motor shaft
E	Supply voltage
R_{fm}	Motor field resistance

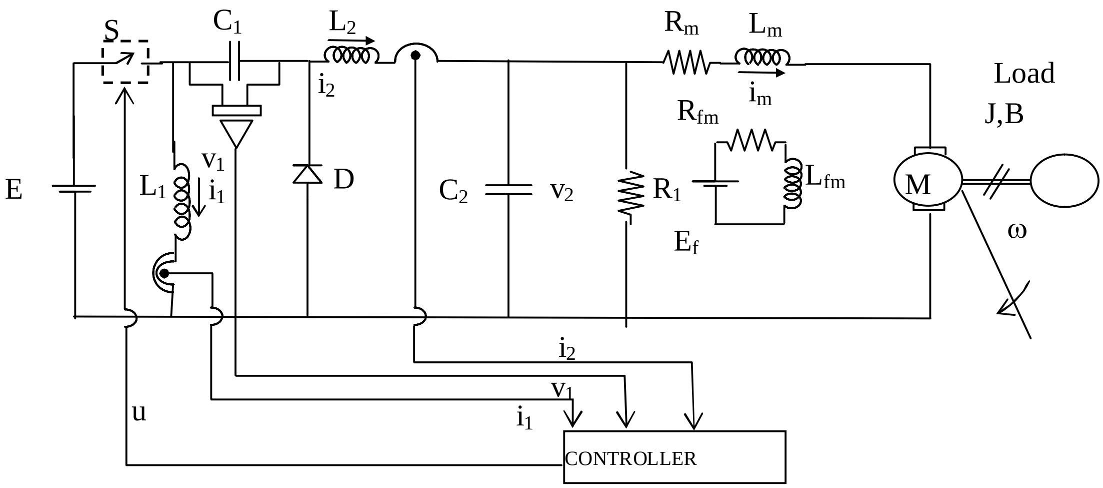


Fig.1 Luo converter fed D.C motor

u	Average control input
N	Speed of the motor shaft
E	Supply voltage
R_{fm}	Motor field resistance

Using matrix notation, the equation (1)- (6) can be written as

$$\dot{x}(t) = (\, J(u) - R\,)\left(\frac{\partial H_x(t)}{\partial x}\right)^T + b\,u + \epsilon \qquad (7)$$

with the state vector $x^T(t) = (i_1, i_2, v_1, v_2, i_m, \omega)$ and the matrices $J(u)$, b, ϵ and R are given as

$$J(u) = \begin{bmatrix} 0 & 0 & \frac{-(1-u)}{L_1C_1} & 0 & 0 & 0 \\ 0 & 0 & \frac{u}{L_2C_1} & \frac{-1}{L_2C_2} & 0 & 0 \\ \frac{(1-u)}{L_1C_1} & \frac{-u}{L_2C_1} & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{L_2C_2} & 0 & 0 & \frac{-1}{L_mC_2} & 0 \\ 0 & 0 & 0 & \frac{1}{L_mC_2} & 0 & \frac{-K}{JL_m} \\ 0 & 0 & 0 & 0 & \frac{K}{JL_m} & 0 \end{bmatrix}$$

$$R = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{R_1C_2^2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{R_m}{L_m^2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{B}{J^2} \end{bmatrix}$$

$$b^T = \left[E/L_1\,, E/L_2\,, 0, 0, 0, 0\right] \qquad (8)$$

$$\epsilon^T = \left[0, 0, 0, 0, 0, \frac{-T_L}{J}\right] \qquad (9)$$

Due to the skew symmetry nature of 'J ' matrix, J does not intervene in the stability of the system. Matrix R is symmetric and positive –semi definite, i.e., $R^T = R \geq 0$.

The total stored energy of the system is given as

$$H(x) = \frac{1}{2}x^T M\, x \qquad (10)$$

where

$$M = \begin{bmatrix} L_1 & 0 & 0 & 0 & 0 & 0 \\ 0 & L_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & C_1 & 0 & 0 & 0 \\ 0 & 0 & 0 & C_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & L_m & 0 \\ 0 & 0 & 0 & 0 & 0 & J \end{bmatrix} \qquad (11)$$

which is positive definite and constant.

3. PASSIVITY-BASED AVERAGE CONTROLLER DESIGN

It is desired to have the motor armature shaft track a certain angular velocity profile $\omega^*(t)$. In this regard, it is assumed that a state reference trajectory $x^*(t)$ satisfies the following open loop dynamics:

$$\dot{x}^*(t) = (J(u^*) - R)\left(\frac{\partial H[x^*(t)]}{\partial x^*}\right)^T + b\,u^*(t) + \epsilon^* \qquad (12)$$

where $u^*(t)$ is the reference control input corresponds to the desired state reference $x^*(t)$ and the vector ϵ^* contains constant torque T_L.

The passivity based control is derived upon the error system dynamics (see [6]& [7]). To this end, define the error between the state and it's reference trajectory which is given by, $e(t) = x(t) - x^*(t)$. Define the control input deviation;

$$e_u(t) = u(t) - u^*(t).$$

Let

$$H(e) = \frac{1}{2}e^T M e \qquad (13)$$

be a quadratic Hamiltonian for the error system. From (13) it can be derived as

$$\left(\frac{\partial H(e)}{\partial e}\right)^T = Me = \left(\frac{\partial H(x)}{\partial x}\right)^T - \left(\frac{\partial H(x^*)}{\partial x^*}\right)^T \quad (14)$$

Subtracting the nominal open loop dynamics (12) from the actual system (7) and define the error:

$\eta = \epsilon - \epsilon^* = 0$

and the error system is derived as

$$\dot{e}(t) = J(u)\left(\frac{\partial H(x)}{\partial x}\right)^T - R\left(\frac{\partial H(e)}{\partial e}\right)^T - J(u^*)\left(\frac{\partial H(x^*)}{\partial x^*}\right)^T + be_u + \eta$$

$$= (J(u) - R)\left(\frac{\partial H(e)}{\partial e}\right)^T + (J(u) - J(u^*))\left(\frac{\partial H(x^*)}{\partial x^*}\right)^T + be_u \quad (15)$$

The skew symmetry matrix J(u) can be written as

$$J(u) = J_0 + J_1 u \quad (16)$$

Where J_0 and J_1 are skew symmetry constant matrices which are given by

$$J_0 = \begin{bmatrix} 0 & 0 & \frac{-1}{L_1C_1} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{-1}{L_2C_2} & 0 & 0 \\ \frac{1}{L_1C_1} & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{L_2C_2} & 0 & 0 & \frac{-1}{L_mC_2} & 0 \\ 0 & 0 & 0 & \frac{1}{L_mC_2} & 0 & \frac{-K}{JL_m} \\ 0 & 0 & 0 & 0 & \frac{K}{JL_m} & 0 \end{bmatrix}$$

$$J_1 = \begin{bmatrix} 0 & 0 & \frac{1}{L_1C_1} & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{L_2C_2} & 0 & 0 & 0 \\ \frac{-1}{L_1C_1} & \frac{-1}{L_2C_2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Hence it follows that

$$\dot{e}(t) = (J(u) - R)\left(\frac{\partial H(e)}{\partial e}\right)^T + J_1\left[\frac{\partial H(x^*)}{\partial x^*}\right]^T e_u + be_u \quad (17)$$

A natural feedback law, defined in terms of the control input error variable e_u, which achieves asymptotic stability of the system, may then be written as

$$e_u = -\gamma\left[\left[\frac{\partial H(x^*)}{\partial x^*}J_1^T + b^T\right]\left(\frac{\partial H(e)}{\partial e}\right)^T\right] \quad (18)$$

Where the constant 'γ' must be > 0.The closed loop exact tracking error dynamics becomes

$$\dot{e}(t) = J(u)\left(\frac{\partial H(e)^T}{\partial e}\right)^T - \widetilde{R}\left(\frac{\partial H(e)}{\partial e}\right)^T \quad (19)$$

Where

$$\widetilde{R} = R + \gamma\left\{\left[J_1\left(\frac{\partial H(x^*)}{\partial x^*}\right)^T + b\right]\left[\frac{\partial H(x^*)}{\partial x^*}J_1^T + b^T\right]\right\}$$

$$= \begin{bmatrix} \gamma\left(\frac{E+x_3^*}{L_1}\right)^2 & \gamma E\frac{(E+x_3^*)}{L_1L_2} & -\gamma\frac{x_1^*}{C_1}\frac{(E+x_3^*)}{L_1} & 0 & 0 & 0 \\ \frac{E(E+x_3^*)}{L_1L_2}\gamma & \frac{E^2}{L_2^2}\gamma & \frac{-Ex_1^*}{C_1L_2}\gamma & 0 & 0 & 0 \\ \frac{-x_1^*}{C_1}\frac{(E+x_3^*)}{L_1L_2}\gamma & \frac{-Ex_3^*}{C_1L_2}\gamma & \frac{x_1^{*2}}{C_1^2}\gamma & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{C_2^2R_1} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{R_m}{L_m^2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{B}{J^2} \end{bmatrix}$$

Since all state variables are strictly positive in practice, matrix $\widetilde{R}$ may be assumed positive definite. Hence with skew symmetry of J(u) and H(e) mentioned in (13) along with the trajectories of the closed loop system , it follows that

$$\dot{H}(e) = \frac{\partial H(e)}{\partial e}\dot{e}(t) = \frac{\partial H(e)}{\partial e}\left[J(u) - \widetilde{R}\right]\left(\frac{\partial H(e)}{\partial e}\right)^T \quad (20)$$

$$= -\frac{\partial H(e)}{\partial e}\widetilde{R}\left(\frac{\partial H(e)}{\partial e}\right)^T < 0 \quad (21)$$

Since $\widetilde{R}$ is positive definite whenever $t \geq 0$, the origin of the error space is an asymptotically stable and due to the bounded nature of u between 0 and 1, the result is not global one.

In terms of converter inductor currents i_1 and i_2 and voltage v_1, the following linear time varying stable feedback control law governs the speed of Luo converter fed DC motor combination to track the reference trajectory $x^*(t)$ with corresponding control input reference trajectory $u^*(t)$ and it can be given as

$$u = u^* + \gamma\left[v_1 i_1^* - v_1^* i_1 - i_2^*(v_1 - v_1^*) - E[(i_1 - i_1^*)] - E[(i_2 - i_2^*)]\right] \quad (22)$$

Notice that when $i_1, i_2, v_1, v_2 \rightarrow i_1^*, i_2^*, v_1^*, v_2^*$ then he average control will be $u \rightarrow u^*$

When 'u' semi globally stabilizes to u^*, voltages, currents of the Luo converter and speed of the motor will reach the corresponding steady state values. The value of $'\gamma'$ can be taken as 0.1.

4. REFERENCE TRAJECTORY GENERATION

In continuation of the derived feedback law (22), it is necessary to generate voltage and current references for the Luo converter circuit i.e., $v_1^*(t)$, $i_2^*(t)$ and $i_1^*(t)$. In order to realize smooth starter for a DC motor, restrictions should be made in the reference profiles so that smooth changes between stationary regimes can be achieved. For the generation of output voltage of Luo converter and it's inductor current or input current, differential parameterizations in terms of the desired angular velocity and the load torque which can be a constant, has to be done. From (1) – (6) v_1^*, i_1^* and i_2^* can be achieved from the following equations (32)-(34)

$$i_1 = \frac{L_2L_mC_1C_2}{Ku(1-u)}\ddddot{\omega} + \left[\frac{L_2C_1(BL_mC_2R_1+R_1R_mJC_2+L_mJ)}{KR_1u(1-u)}\ddddot{\omega}\right] + \left[\left[\frac{L_2C_1(BR_1R_mC_2-R_1k^2C_2+BL_m+R_mJ+R_1J)+R_1JL_m}{KR_1u}\right] + \left[\frac{L_mC_2J}{K}\left(\frac{u}{1-u}\right)\right]\right]\dddot{\omega} + \left[\frac{L_2C_1(BR_m-K^2+BR_1)+R_1(BL_m+JR_m)}{KR_1u} + \left(\frac{u}{1-u}\right)\frac{(BL_mC_2R_1+R_1R_mJC_2+L_mJ)}{K}\right]\ddot{\omega} + \left[\frac{C_1}{u(1-u)}\left(\frac{BR_m-K^2}{K}\right) + \left(\frac{u}{1-u}\right)\left(\frac{BR_1R_mC_2-R_1k^2C_2+BL_m+R_mJ+R_1J}{KR_1}\right)\right]\dot{\omega} + \left[\frac{BR_m-K^2+BR_1}{KR_1}\frac{u}{1-u}\omega\right] + \left[\left(\frac{u}{1-u}\right)\left(\frac{\widehat{T_L}}{K}\left(\frac{R_m}{R_1}+1\right)\right)\right] \quad (29)$$

$$v_1 = \frac{L_2L_mC_2J}{Ku}\ddddot{\omega} + \frac{L_2(BL_mC_2R_1+R_1R_mJC_2+L_mJ)}{KR_1u}\dddot{\omega} - E + \left[\frac{L_2(BR_1R_mC_2-R_1K^2C_2+BL_m+R_mJ+R_1J)+R_1L_mJ}{KR_1u}\right]\ddot{\omega} + \frac{L_2(BR_m-K^2+BR_1)+R_1(BL_m+JR_m)}{KR_1u}\dot{\omega} + \frac{1}{u}\left(\frac{BR_m}{K}-K\right)\omega + \frac{R_m}{u}\frac{\widehat{T_L}}{K} \quad (30)$$

$$i_2 = \frac{L_mC_2J}{K}\dddot{\omega} + \left(BL_mC_2 + R_mJC_2 + \frac{L_mJ}{R_1}\right)\frac{1}{K}\ddot{\omega} + \frac{BR_1R_mC_2-R_1K^2C_2+BL_m+R_mJ+R_1J}{KR_1}\dot{\omega} + \frac{BR_m-K^2+BR_1}{KR_1}\omega + \frac{\widehat{T_L}}{K}\left[\frac{R_m}{R_1}+1\right] \quad (31)$$

Under equilibrium conditions

$$i_2^* = \frac{BR_m-K^2+BR_1}{KR_1}\omega^* + \frac{\hat{T}_L}{K}\left[\frac{R_m}{R_1}+1\right] \quad (32)$$

$$v_1^* = \left(\frac{BR_m}{K}-K\right)\frac{\omega^*}{u^*} + \frac{R_m}{u^*}\frac{\hat{T}_L}{K} - E \quad (33)$$

$$i_1^* = \left(\frac{BR_m-K^2+BR_1}{KR_1}\frac{u^*}{1-u^*}\right)\omega^* + \frac{u^*}{1-u^*}\left(\frac{\hat{T}_L}{K}\left[\frac{R_m}{R_1}+1\right]\right) \quad (34)$$

In order to define the trajectory, Bezier polynomial of tenth order is used [46]. For the desired speed profile, the polynomial is given by,

$$\begin{aligned} \omega^*(t) &= \omega_{ini} && \text{for } t<t_{ini}; \\ &= \omega_{fin} && \text{for } t>t_{fin}; \\ &= \omega_{ini} + \varnothing(\omega_{fin} - \omega_{ini}) && \text{for other values of 't'} \end{aligned} \quad (35)$$

where the expression for $\varnothing$ is given below.

$$\varnothing = 252\left(\frac{(t-t_{ini})}{(t_{fin}-t_{ini})}\right)^5 - 1050\left(\frac{(t-t_{ini})}{(t_{fin}-t_{ini})}\right)^6 + 1800\left(\frac{(t-t_{ini})}{(t_{fin}-t_{ini})}\right)^7 - 1575\left(\frac{(t-t_{ini})}{(t_{fin}-t_{ini})}\right)^8 + 700\left(\frac{(t-t_{ini})}{(t_{fin}-t_{ini})}\right)^9 - 126\left(\frac{(t-t_{ini})}{(t_{fin}-t_{ini})}\right)^{10}$$

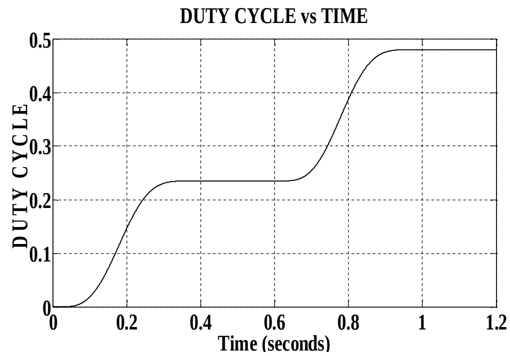
5. SIMULATION RESULTS

In order to validate the features of ETEDPOF, Luo converter is tested with DC motor. State constructors are used for simulating Luo converter in MATLAB. The specifications for the setup are mentioned in TABLE I.

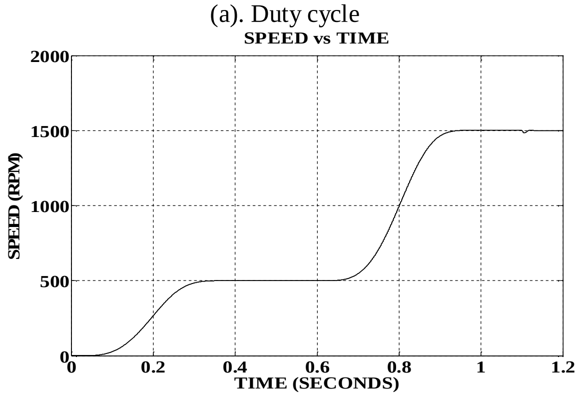
TABLE I. SPECIFICATIONS OF LUO CONVERTER AND DC MOTOR

S.No	Luo Converter		DC Motor Armature side	
S.No	L_1	18mH	P_o	1 HP
1.	C_1	20µF	E_a	180/220 Volts
2.	L_2	2.769mH	I_a	5.1 A
3.	C_2	440.1µF	N	1500/1800 RPM
4.	E	220 V	L_a	111.6mH
DC Motor Field side			L_{af}	3.44 H
5.	R_f	696.1 Ω	J	3.4e-3 kg*m^2
6.	E_f	180/220 V	B	2.7e-3 Nm/rad
7.	L_f	25.23		

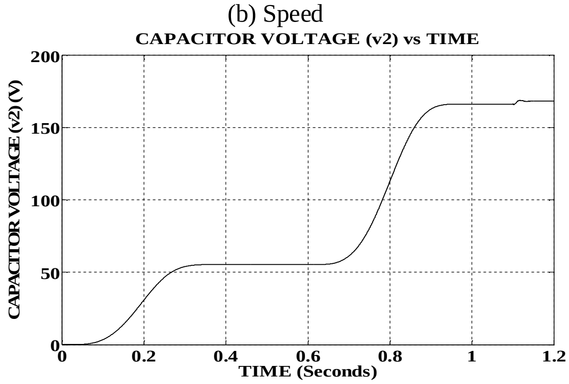
The response of Luo converter fed DC motor with ETEDPOF controller is shown in Fig.2. Soft starter is implemented for the DC motor by measuring only the converter currents and voltage. The armature currents are well within the limits (Fig. 2(e)). The speed profiles are based on the Bezier polynomial. The speed references are taken as 500 RPM and then 1500 RPM. The other responses are obtained satisfactorily and it is shown in Fig 2. When the motor is loaded with 1 Nm at 1.1 second, v_1^*, i_1^* and i_2^* are up dated by using (32) to (34). With that updated value, control function is updated and satisfactory speed response is obtained (Fig. 2.(b)).



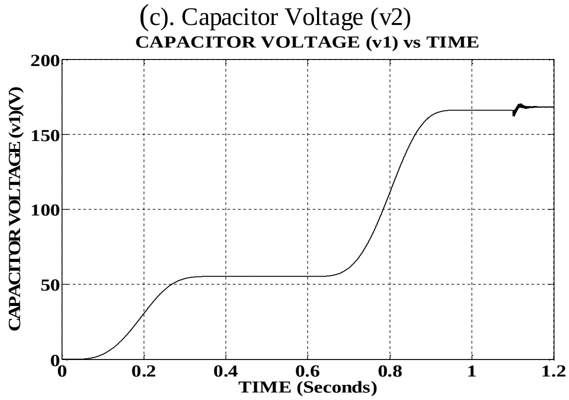
(a). Duty cycle



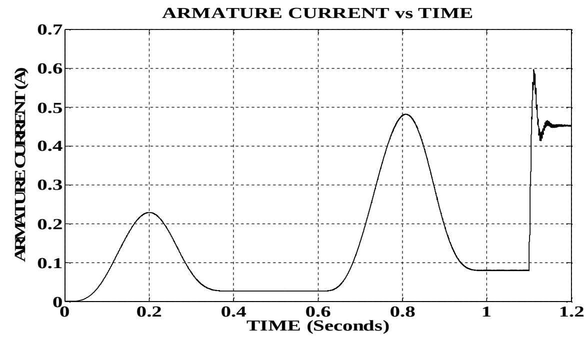
(b) Speed



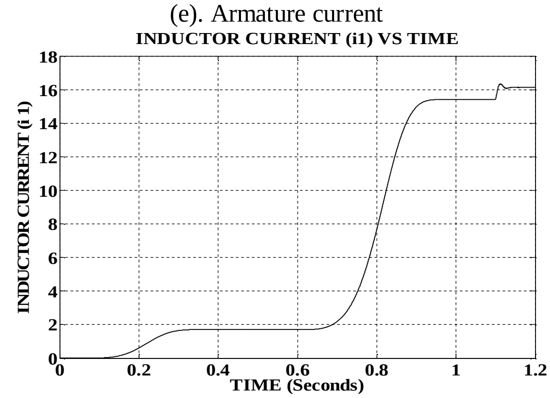
(c). Capacitor Voltage (v2)



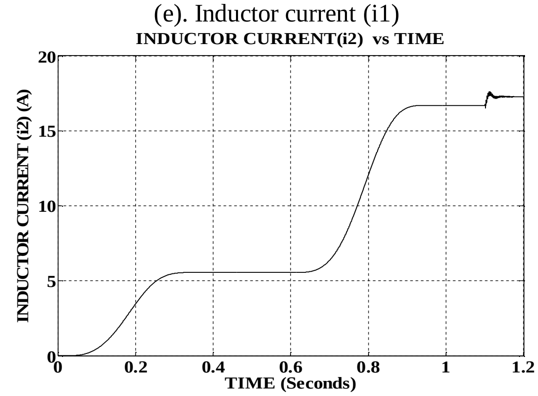
(d). Capacitor Voltage (v1)



(e). Armature current



(e). Inductor current (i1)



(f). Inductor current (i_2)

Fig.2 Responses for control of Luo Converter fed DC motor with ETEDPOF.

6. CONCLUSION

In this paper soft starter for Luo converter fed D.C. motor is implemented by measuring converter currents and voltages only. The stabilization of speed tracking profile is achieved using ETEDPOF controller with and without loading the D.C. motor. The results obtained from experimentation confirm the features of ETEDPOF controller. As the results are promising, ETEDPOF can be extended for other converters.

7. REFERENCES

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