International Innovative Research Journal of Engineering and Technology
Melange Publications ISSN NO:2456-1983

Design of PSO Based KY Boost Converter to Reduce Output Ripple Voltage

Karthikeyan.T[1], Balakumar.A[2], Sathyanarayanan.M[3], Senthilkumar.R[4], Sugavanam.K. R[5]

[4,5]Assistant professor, Dept of EEE Vel tech high tech engineering college Chennai, India

[1]tkarthikchennai@gmail.com,

[2] bala1to4@gmail.com,

[3]Smsathya66@gmail.com,

[4]rskumar.eee@gmail.com

[5]sugavanamkr@gmail.com.

Abstract:

The main objective of this paper is to reduce the output ripple voltage and settling time of KY Boost converter. This converter operates under continuous transmission form with small output volt swell in the sequence of few mV, quick transient response and settling time gaining larger voltage conversion ratio. In this paper, particle swarm optimization algorithm (PSO) tuned PI controller is proposed to reduce the output ripple voltage further and achieve rapid settling time when compared to the PI and PID controllers. The simulated results are executed in MATLAB/SIMULINK showing that there is a considerable reduction in output voltage ripple in the order of mV along with quick settling time as compared to the existing system.

Keywords: Boost converter, KY converter, Output Voltage Ripple, Particle Swarm Optimization (PSO), PI controller.

I.INTRODUCTION

For the betterment of computing and communication devices such as Analog circuit, Personal Digital Assistant (PDA), MP3 player, Bluetooth devices, amplifier etc., it is necessary to boost up the output voltage for fixed input voltage. In such cases designer should concentrate on the output voltage ripple, settling time and transient response of the converter. In prevailing non-isolated step up DC - DC voltage converters leads to formation of large voltage ripples at output. In order to control this, the methods used are Equivalent Series Resistant (ESR) Capacitor [1], adding an inductance – capacitance (LC) filter [2]. Though these methods have good load transient response but it is difficult to achieve right-hand zero under Continuous Conduction Mode (CCM) [3]–[9] practically. The established control techniques for DC-DC converter are coupling inductors [3], voltage control techniques [4]–[9], sliding mode converter [10] and loop bandwidth control [11] for the reduction of output voltage ripples. It is clear that these systems [3]–[9] have one right – half plane zero with CCM which produces good transient response but achieving this in practice is difficult. In this paper, the output voltage ripple of the KY converter [13] is controlled based on Particle Swarm Optimisation techniques10. The parameter use for performance are estimated in time domain. The converter along with **PSO** tuning is represented in MATLAB simulink model and the results obtained from simulation evince that there is a reduction in output voltage ripple with quick settling time compared to existing system.

II.PROPOSED SYSTEM

In this proposed system particle swarm optimization algorithm [11] is implemented in the controller to select the firing angle of KY converter switches in order to reduce the output voltage ripple which is represented by the block diagram in following figure 1. The main blocks of proposed system consist of KY converter, comparator, PWM generator, controller tuned by particle swarm optimization (PSO) algorithm. The comparator compares the output voltage (V_O) with the reference signal voltage (V_{ref}) and generates an error signal (e) . The error signal is fed into PSO based controller and the output of the controller is a duty cycle (d) which is fed into the PWM generator to produce the switching pulse which drives the converter. The main blocks of proposed system consist of KY converter, comparator, PWM generator, controller tuned by particle swarm optimization (PSO) algorithm. The comparator compares the output voltage (V_O) with the reference signal voltage (V_{ref}) and generates an error signal (e) . the error signal is fed into PSO based PI controller and the output of the controller is a duty cycle(d) which is fed into the PWM generator to produce the switching pulse which drives the converter. A.Circuit description.The positive output KY converter [4]-[5] shown in the following fig.1. This circuit is a combination of KY converter and SR boost converter which operates in two modes based on the switching sequence.

International Innovative Research Journal of Engineering and Technology
Melange Publications ISSN NO:2456-1983

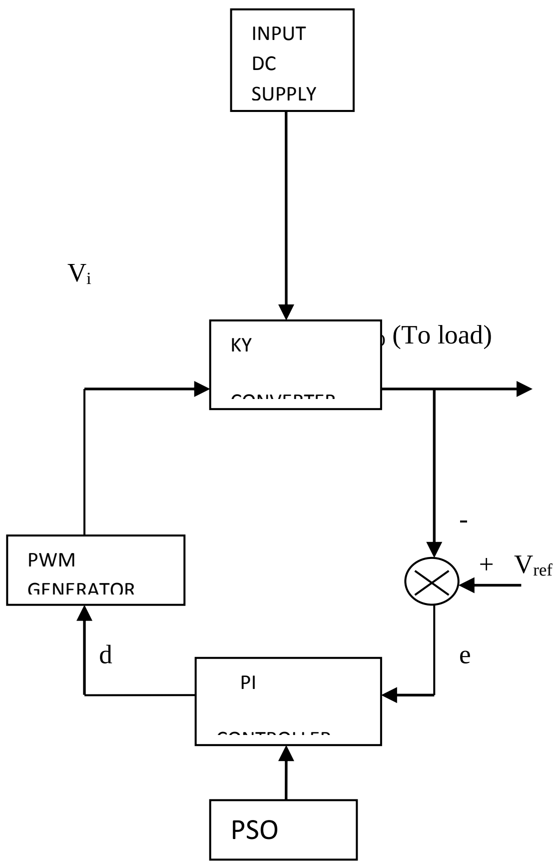


FIG1: BLOCK DIAGRAM

III.BASIC OPERATION OF POSITIVE OUTPUT KY BOOST CONVERTER

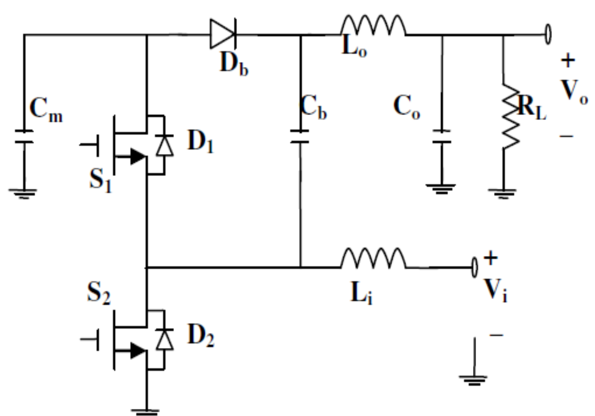


Fig2+ve BOOST CONVERTER

The KY converter consists of two switches S_1 and S_2 with protective diode D_1 and D_2 respectively, one capacitor C_b for transferring energy , one output inductor Lo, and one output Capacitor C_0 ,and one buffer capacitor Cm. It has inductance at both input and output side so output current ripple is low which tends to low output voltage ripple around 200mv. It is a non- isolated converter works in continues conduction mode with conversion voltage ratio of 1plus d, where d is a duty cycle of the controller. Based on the mode of operation the firing pulse of the corresponding switches was given by the PSO based controller with response to the error signal.

B. Modes of operation

KY converters has two modes of operation based on switching sequence

Mode 1: As soon as the switch s_1 turned OFF and s_2 turned ON, the capacitor C_m discharged and the capacitor C_b is charged the voltage across L_i is V_I there by L_I is magnetized and Lo is demagnetized, the current flows through the L_O is the difference between the current through C_m and current through R_L, the current through C_O is the different between current through L_O and current through R_L and the current through capacitor C_m is the sum of current through energy transfer capacitor C_b output inductor L_O which is represented in differential equation (1)

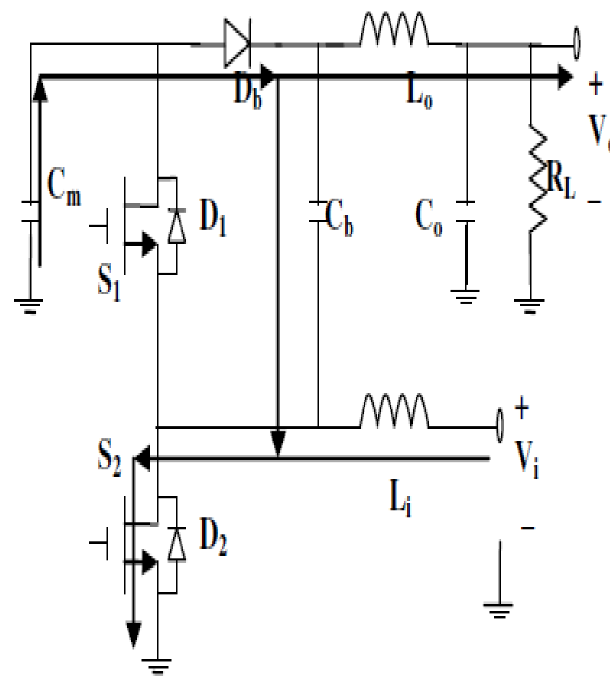


Fig 3: MODE 1 OPERATION

$$\begin{cases} Li\dfrac{\partial iLi}{\partial t} = vi, \\ Lo\dfrac{\partial iLo}{\partial t} = vcm - vo, \\ Co\dfrac{\partial vo}{\partial t} = iLo - \dfrac{vo}{RL}, \\ Cm\dfrac{\partial vcm}{\partial t} = -icb - iLo. \end{cases} \quad (1)$$

Mode 2: when the switch S_1 turned OFF and S_2 turned ON the capacitor C_b is discharged and the capacitor C_m is charged and voltage across L_i is calculated by the difference between V_I and V_{cm}, thereby magnetizing Lo and L_i is demagnetized. The voltage across L_O is the difference between voltage $2V_{cm}$ and $V_{O.}$ The current through C_O is the difference between current through L_O and current through R_L, and the current through capacitor C_m is the difference between the current through output inductor L_O and input inductor L_i respectively which is represented in differential equation (2).

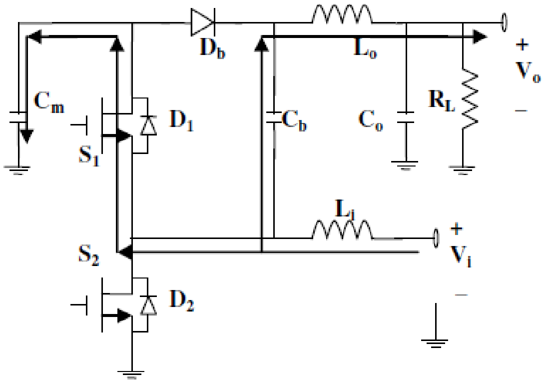


Fig 4: MODE 2 OPERATION

$$\begin{cases} Li\dfrac{\partial iLi}{\partial t} = vi - vcm, \\ Lo\dfrac{\partial iLo}{\partial t} = 2vcm - vo, \\ Co\dfrac{\partial vo}{\partial t} = iLo - \dfrac{vo}{RL}, \\ Cm\dfrac{\partial vcm}{\partial t} = iLi - iLo. \end{cases} \quad (2)$$

From equation (3), we can obtain the average value of voltage and current, which is represent as x

$$\langle x \rangle = \frac{1}{Ts}\int_0^{Ts} x d\tau . \quad (3)$$

The average inductance and capcitor from equation (1)-(3) represented in equation (4):

$$\begin{cases} Li\dfrac{\partial\langle iLi\rangle}{\partial t} = \langle vi\rangle - (1-d)\langle vcm\rangle, \\ Lo\dfrac{\partial\langle iLo\rangle}{\partial t} = (2-d)\langle vcm\rangle - \langle vo\rangle, \\ Co\dfrac{\partial\langle vo\rangle}{\partial t} = \langle iLo\rangle - \dfrac{\langle vo\rangle}{RL}, \\ Cm\dfrac{\partial\langle vcm\rangle}{\partial t} = -\langle iLo\rangle + (1-d)\langle iLi\rangle - d\langle icb\rangle, \end{cases} \quad (4)$$

where d is the duty cycle of PWM generator. The voltage conversion ratio can be obtained by following equation (5). V_0/V_i=2-d/1-d (5)

The specification of KY boost converter is given in following TABLE1.

TABLE I. SPECIFICATIONS OF KY BOOST CONVERTER

Parameter	Symbol	Value	Unit
Input voltage	V_i	12	V
Rated output voltage	V_0	36	V
Rated load current	I_0	2.5	A
Buffer capacitance	C_m	1000	µF
Output capacitor	C_0	470	µF
Output and input inductor	L_0,L_i	15	µH
Energy transfer capacitor	C_b	680	µF
Output capacitor	C_0	470	µF
Load resistor	R_L	14.4	Ω
Switching frequency	F_S	195	kHz

IV.PARTICLE SWARM OPTIMIZATION

In recent years, the research community is paying more attention towards PSO for research purposes. It is initially proposed by James Kennedy and Russell Eberhart in 1995. It uses a number of particles that makes a swarm to move in the search space for finding the best solution. Each particle is constantly searching for the optimum solution which has a velocity because of the movement of particle and remembers its own personal best position as well as the neighbour's best position. The particles in the swarm co-operate each other and exchange their information about what they've discovered in the places they have searched. A particle finds the finesses of those in its neighbourhood and uses the position of the particle with best fitness. This position leads to adjust the particle's velocity. To get the new particle's velocity, the following calculation is used. New particle velocity = current velocity + weighted random portion in the direction of its personal best + weighted random portion in the direction of the neighbourhood best. There are two types of neighbours.They are,1. Geographical neighbours 2. Social neighbours

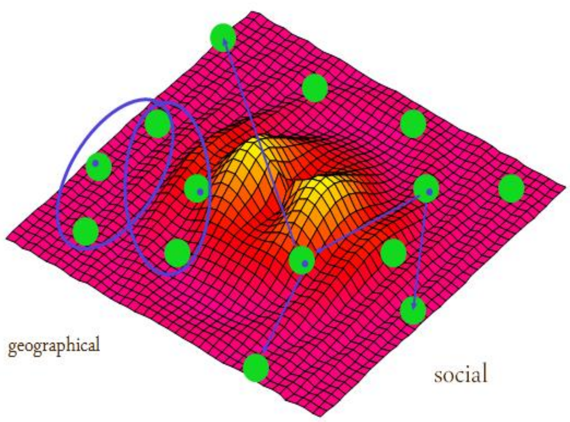
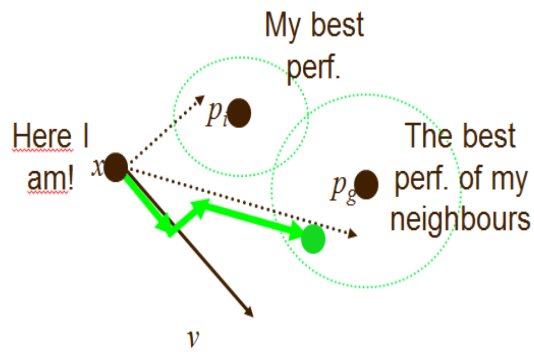


FIG 5:Neighbourhoods

Particles tune their positions according to a ``Psychosocial compromise'' among what an person is relaxing by means of, and what will society expect. Each particle tries to modify its position with the follow in sequence:

- the present position,
- the present velocity,
- the distance between the current position and pbest,
- the detachment among the current spot and the finest.

- The modification of the particle's position can be scientifically model according the following equation (6)



$$V_i^{k+1} = wV_i^k + c_1\, rand_1(\ldots) \times (pbest_i - s_i^k) + c_2\, rand_2(\ldots) \times (gbest - s_i^k) \quad \ldots.. \quad (6)$$

where,

v_i^k : velocity of agent i at iteration k,
w: weightingfunction,
c_j: weightingfactor,
rand : regularly spread casual numeral among 0 and 1

s_i^k : current position of agent i at iteration k,
$pbest_i$: p best of mediator i,
gbest: gbest of the cluster.

In this proposed system particle swarm optimization (**PSO**) algorithm is used to tune the **PI** controller in order to reduce the output voltge ripple of KY converter. The output voltage is compared with the reference signal, the generated error signal is injected to **PSO** tuned PI controller. **PSO** algorithm is used to select the optimized K_P,K_I value and this gives corresponding dutycycle[d] at the output side of the controller.The dutycycle[d] is fed into PWM generator working at the frequency of 195 KHZ ,the output of the PWM generator is the firing angle given to the swithches of the KY converter.

V.SIMULATION RESULT:

The MATLAB SIMULINK for the proposed KY converter was shown in the figure from 6 to 8.

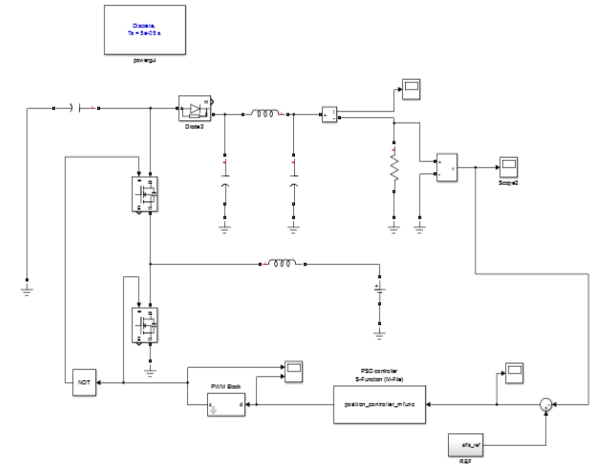
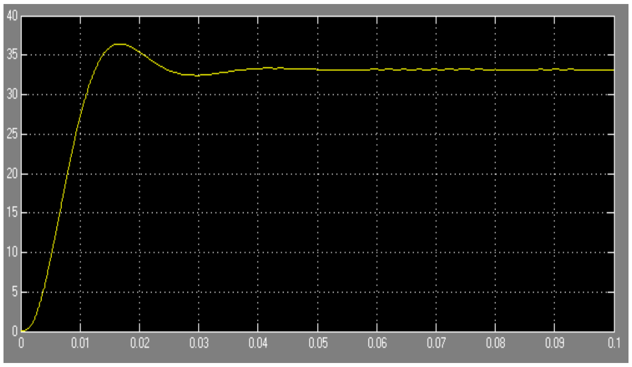


Fig 6: SIMULINK MODEL OF PROPOSED PSO BASED KY CONVERTER



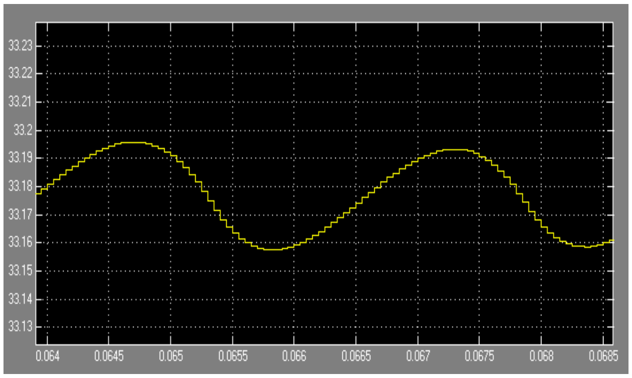


Fig 8:output voltage ripple waveform of PSO based KY boost converter

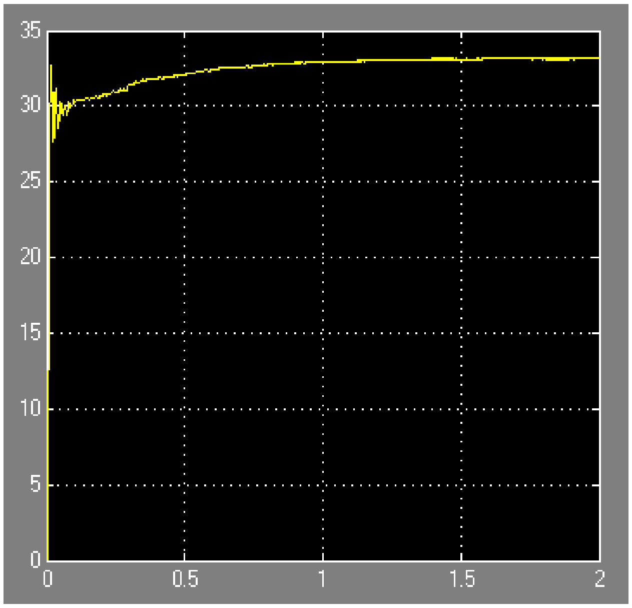


Fig 7: Output Voltage Waveform Of PI controlled KY boost Converter

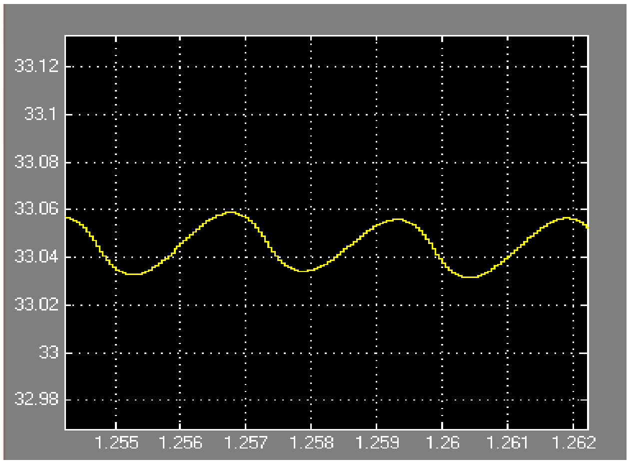


Fig 8: Output ripple Voltage Waveform Of PI controlled KY boost Converter

Simulation was performed for both PI controlled KY boost converter and PSO tuned PI controlled KY converter. When compared to the existing system, PARTICLE SWARM OPTIMIZATION (PSO) tuned PI controller works more efficient then PI and PID controllers**.**

VI. CONCLUSION

By using PSO tuned PI controlled KY Boost Converter, the output voltage ripple and settling time is reduced when compared to the existing PI and PID controllers.

REFERENCES

[1] M. K. Kazimierczuk, R. S. Geise, A. Reatti, "Small-signal analysts of a PWM boost DC-DC converter with a non-symmetric phase integral lead controller", in Proc. INTELEC 95, Dayton, OH, 1995.

[2] R. B. Ridley, "Secondary LC filter analysis and design techniques for current-mode controlled converters", IEEE Trans. Power Elec., vol. 3,pp. 499–507, 1988. [Online].Available:http://dx.doi.org/ 10.1109/63.17972

[3] H. B. Shin, J. G. Park, S. K. Chung, H. W. Lee, T. A. Lipo, "Generalised steady-state analysis of multiphase interleaved boostconverter with coupled inductors", in IEE Proc. Electr. Power Appl., 2005, vol. 3, pp. 584–594. Available:http://dx.doi.org/ 10.1049/ip-epa:20045052

[4] F. L. Luo, "Positive output Luo converters voltage lifting technique", in IEE Proc. Electr. Power Appl., 1999, vol. 4, pp. 415–432. [Online]. Available: http://dx.doi.org/10.1049/ip-epa:19990291

[5] F.L. Luo, H. Ye, "Positive output super-lift converter", IEEE Trans.Power Elec., vol. 18, pp. 105113,2003.[Online].Available:http://dx.doi.org/10.1109 /TPEL.2002.807198

[6] M. Zhu, F. L. Luo, "Development of voltage lift technique on double output transformerless DC-DC converter", in Proc. IEEE IECON Conf., 2007, pp. 1983–1988.

[7] M. Zhu, F. L. Luo, "Implementing of developed voltage lift technique on SEPIC, Cuk and double-output DC-DC converters", in Proc. IEEE ISIE Conf., 2001, vol. 2, pp. 723–727.

[8] X. Chen, F.L. Luo, H. Ye, "Modified positive output Luo converters",in Proc. IEEE PEDS, 1999, vol. 1, pp. 450–455.

[9] F. L. Luo, H. Ye, "Negative output super-lift converters", IEEE Trans.Power Elec., vol. 18, pp. 1113–1121, 2003. [Online]. Available: http://dx.doi.org/10.1109/TPEL.2003.816185

[10] S.M.GirirajKumar "PSO based Tuning of a PID Controller for a High Performance Drilling Machine" ©2010 International Journal of Computer Applications (0975 - 8887)Volume 1 – No. 19

[11] Kouzou A," Current/Voltage Ripple Minimization of DC/DC Interface System for Renewable Energies" Acemp - Electromotion 2011, 8 - 10 September 2011 İstanbul – Turkey

[12] Zwe-Lee Gaing, " A particle swarm optimization approach for optimum design of PID controller in AVR system", IEEEtransactions on energy conversion,November 6,(2002).

[13] K. I. Hwu, KY Converter and Its Derivatives IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 24, NO. 1, JANUARY 2009

[14] Kouzou, A.; Mahmoudi, M.O.; Boucherit, M.S, « Fuel Cell SHEPWMDC/DC chopper interface based on particle swarm optimization", 7th International Multi-Conference on Systems Signals and Devices (SSD),

[15] Kouzou A, Mahmoudi M.O, Boucherit M.S "Particle Swarm Optimization Applied for the Improvement of the PWM DC/DC Choppers OutputVoltage" ICEE2009.Boumerde, Algeria. 5-7 December 2009

AUTHORS BIOGRAPHY

Mr.Karthikeyan T is a UG student pursuing his degree in Electrical Engineering at Vel Tech High Tech Engineering College

Mr.Balakumar A is a UG student Pursuing his degree in Electrical Engineering at Vel Tech High Tech Engineering College

Mr.Sathyanarayanan M is a UG student Pursuing his degree in Electrical Engineering at Vel Tech High Tech Engineering.