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Study on Performance of DC-DC Converters

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ABSTRACT: DC-DC converters are switched power converters. These converters are used to convert one DC voltage to other. These converters are drastically used in industry as well as in research. One of the main limitations of these converters is unregulated supply of voltage and current. The model of the converter system varies from the ON state to the OFF state and hence traditional methods of controller design based on approximate transfer function models do not yield dynamic response at different operating points of the converter system. To overcome these problems there are various control techniques used in combination with these converters. In this review various control techniques are being presented.

KEYWORDS: Controller design, digital control, dynamic performance, power converter, switching frequency.

I. INTRODUCTION

DC-DC converters provide a variable DC output voltage, lower or higher than the input DC voltage. The main problem with operation of DC-DC converter is unregulated power supply, which leads to improper function of DC – DC converters. There is various analog and digital control methods used for dc-dc converters.

DC-DC converters are intrinsically non-linear circuits and it is difficult to obtain accurate models that take into account all parasitic elements that influence dynamic behaviour. The DC-DC converter inputs are generally unregulated DC voltage input and the required outputs should be a constant or fixed voltage. Application of a voltage regulator is that it should maintains a constant or fixed output voltage irrespective of variation in load current or input voltage. Various kinds of voltage regulators with a variety of control schemes are used to enhance the efficiency of DC-DC converters.

DC-DC converters with computerized digital control methods have become more efficient because of high productivity, low power utilization, higher resistance to natural changes, for example, temperature and maturing of parts, capacity to interface effortlessly, of programmability and to actualize advanced control plans. Various techniques have been developed to meet the requirement of output voltage and at the same time it is also necessary to get more resolution to increase precision. It is also used to develop new control methods that can utilize the advantages of the digital controller so as to improve the dynamic performance of the switching power converters.

There are various types of DC-DC converters required for particular purpose like Buck, Boost, Buck and Boost, Cuk and Flyback. All DC-DC converters have the specific configurations to complete the tasks. Varieties in DC-DC converter required different type of controlling techniques because single technique cannot be applied to all converters as the all have different specifications. Aim of this paper is to have an overview of all the control techniques used to facilitate the performance of various kinds of DC-DC converters.

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II. RELATED WORK

- [1] Abilio Parriera, Floriberto Lima and Marcelino Santos, “Digital Modular Control of High Frequency DC-DC Converters”, *Microelectronics Journal*, Vol.45, 2014, pp. 1254-1260.

This paper presents a solution for controlling integrated DC–DC converters with high switching frequency (420 MHz). The increase of the switching frequency is a trend biased by output filter volume restrictions and integration demand. The control of DC–DC converters operating at high frequency presents an opportunity to speed up the converter response time but also a challenge specially for the control solution, quiescent current and to limit the sensitivity to process and operating conditions for the mixed signal circuits involved. The solution presented in this work relies on separating the duty-cycle into three parts: a load-free value that depends only on the input and output voltages, a transient fast correction contribution, and an accurate compensation for the IR drop that depends on the load current. The load-free portion of the duty-cycle has a compensation of PVT variations and the fast transient part of the duty-cycle uses a non-linear sliding mode control solution.

- [2] Esmail Mirzaei and Esmail Mirzaei, “Auto Tuning PID Controller Using Chaotic PSO Algorithm for a Boost Converter”, 13th Iranian Conference on Fuzzy Systems (IFSC), 2013.

Improving dynamic response of DC-DC converters which are nonlinear and complicate systems is an interesting challenge in power electronics. This paper presents the design and implementation of digital PID controller using the chaotic particle swarm optimization (CPSO) for a Boost converter and proposes an approach for auto tuning converter optimum start up response. When the system starts, processor unit analyses the open loop startup response of converter and prepares optimum response during some iteration using CPSO algorithm. Chaotic mapping using logistic map sequences increases its convergence rate and resulting precision.

- [3] Hussain K. Sayed, “Modeling and Control of a Buck DC-DC Converter Based on Artificial Neural Network”, *International Journal of Scientific & Engineering Research*, Vol.4, No.11, pp. 1224-1233, 2013.

The dc-dc converters are highly efficient tools to supply power to different systems, they have a nonlinear behaviour and variations at their main parameters could affect their stability. This paper proposes the Artificial Neural network (ANN) methodology to control the output voltage of a dc- dc buck converters. The mathematical model and simulation of the nonlinear dc-dc buck converter is represented in this work .The conventional PID controller of a dc-dc converter is illustrated as an example of comparison. The proposed technique is evaluated on a dc-dc buck converter under different operating conditions (no-load and full load condition) by using MATLAB Simulink software. The results proved the fast response and robustness of the proposed neural controller with no significant additional cost were compared with traditional PID controller technique.

III. CURRENT MODE CONTROL OF DC-DC CONVERTER

For current-mode control there are three things to consider:

Current-mode operation: An ideal current-mode converter is only dependent on the DC or average inductor current. The inner current loop turns the inductor into a voltage-controlled current source, effectively removing the inductor from the outer voltage control loop at DC and low frequency.

Modulator gain: The modulator gain is dependent on the effective slope of the ramp presented to the modulating comparator input. Each operating mode will have a unique characteristic equation for the modulator gain.

Slope compensation: The requirement for slope compensation is dependent on the relationship of the average current to the value of current at the time when the sample is taken. For fixed-frequency operation, if the sampled current were equal to the average current, there would be no requirement for slope-compensation.

Whether the current-mode converter is peak, valley, average, or sample-and-hold is secondary to the operation of the current loop. As long as the DC current is sampled, current-mode operation is maintained. The current-loop gain splits the complex-conjugate pole of the output filter into two real poles, so that the characteristic of the output filter is

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set by the capacitor and load resistor. Only when the impedance of the output inductor equals the current-loop gain does the inductor pole reappear at higher frequencies.

It is more complex than VMC as it contains dual loop including voltage and current control loops. There are various applications of CMC for different applications. After sensing the inductor current it is used to control the duty cycle. An error signal is produced after comparing the output voltage V_o with fixed reference voltage V_{ref} and this error signal is used to generate control signal i_c . The next step is to sense inductor current and compare it with control signal i_c to generate the duty cycle of particular frequency and drive the switch of the converter. All responses depend on the position of feedback loop as if the feedback loop is closed, the inductor current is proportional to the control signal i_c and the output voltage becomes equal to reference voltage V_{ref} .

Fig.1 shows the operation of the current mode control of the DC-DC converter.

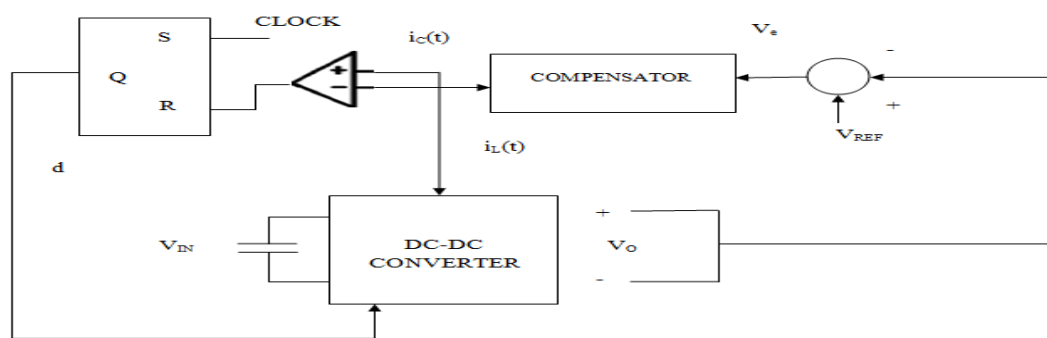


Fig.1 Current Mode Control of DC-DC Converter

IV. VOLTAGE MODE CONTROL DC-DC CONVERTER

It is a type of single loop controller connected to a reference voltage, so at first output voltage is measured and compared to a reference voltage. This VMC method is used in research as well as in industry due to its easy implementation. It uses measured output and reference voltage to generate the control voltage. After this the control voltage is used to determine the switching duty ratio by comparison with a constant frequency waveform. This duty ratio is used to maintain the average voltage across the inductor. This will eventually bring the output voltage to its reference value and helps in the delivery of constant voltage without any variation.

Fig.2 explains the general functioning of the voltage mode control of DC-DC converter. The reference voltage is given as the input which is compensated and given to the converter through the comparator.

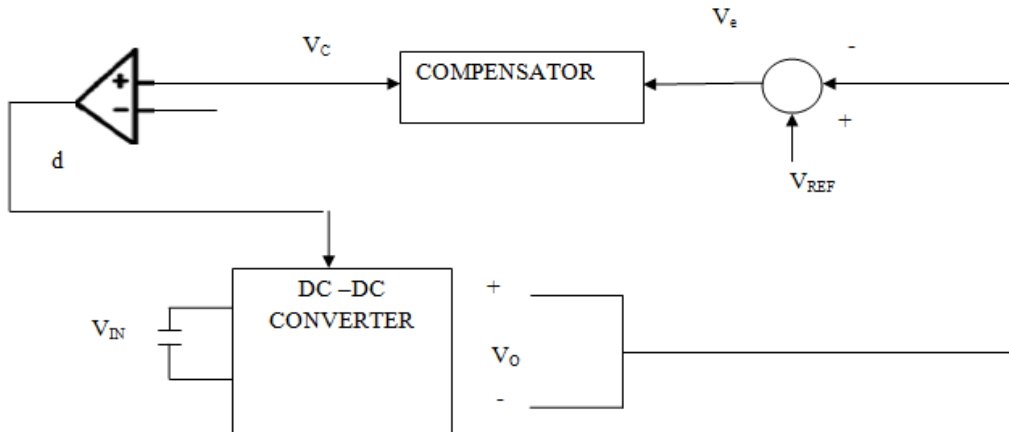


Fig.2 Voltage Mode Control of DC-DC Converter

V. PID CONTROL BASED DC-DC CONVERTER

The Proportional-Integral-Derivative (PID) controller can be used to control any measurable variable, as long as this variable can be affected by manipulating some other process variables. Many control solutions have been used over the time, but the PID controller has become the ‘industry standard’ due to its simplicity and good performance. PID control is one of the oldest and classical control technique used for DC-DC converters. It uses one of its families of controllers including P, PD, PI and PID controllers. These different combinations will gives us various ways to regulate dc power supply in these converters. Due to the various advantages of PID it is widely used for industrial applications in the area of power electronics. One of the main causes for the use of this classical technique still in industrial applications is easy implementation of tuning method like Ziegler-Nichols tuning procedure by which we can optimise proportional, integral and derivative term of this control method needed to achieve a desired closed-loop performance.

Fig.3 shows a proportional integral derivative controller (PID Controller) is a generic control loop feedback mechanism widely used in industrial control system as well as in research. This approach is often viewed as simple, reliable, and easy to implement. PID controllers are commonly used as controllers for boost converters.

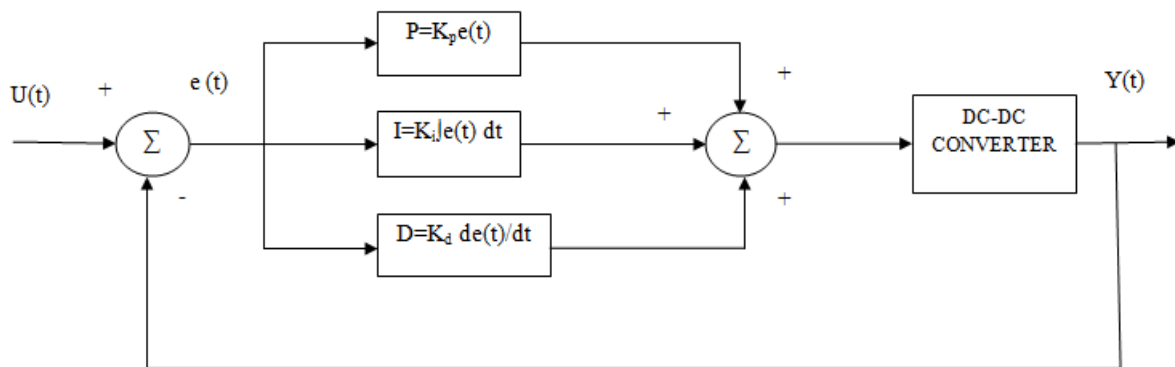


Fig.3 PID Control Based DC-DC Converter

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VI. MODEL PREDICTIVE CONTROL BASED DC-DC CONVERTER

A new and more direct model predictive control approach is proposed based on the original continuous time hybrid model of converters. The key idea is to make full use of the property that the number of modes is finite and transform the optimization of the squared area of output voltage error over a finite time interval into a search problem for the optimal switching sequence. This combinatory optimization problem can be computed effectively within the stringent switching period. The discrete time model predictive control (MPC) is introduced, based on a discrete time piecewise affine (PWA) modeling of the converters in which the duty cycle is regarded as the constrained input. This discrete time PWA model can capture the hybrid dynamics of systems at the sampling instants. The MPC schemes have been developed by minimizing certain output voltage error and the change of duty cycle.

Fig.4 shows that hybrid system methods can be applied to DC-DC converters. The reference signal is to the MPC block where the output signal that is to be obtained are predicted and compared with the model. The signal is the given to the DC-DC converter.

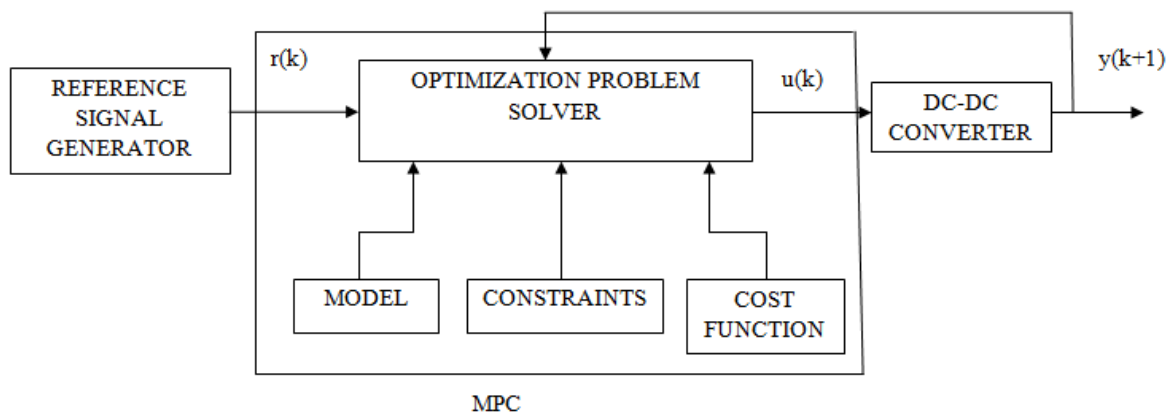


Fig.4 Model Predictive Control Based DC-DC Converter

VII. ADAPTIVE CONTROL BASED DC-DC CONVERTER

Adaptive Control plays vital role in power conversion, provides more precise control, greater system reliability and improved mean time between failures (MTBF) in systems such as computers and networking equipment. Traditional, analog power control systems are completely non-adaptive, employing components such as resistors to implement fixed compensation loops. And even many of the newer digital power conversion products offer little or no real adaptive capabilities. A true adaptive system has the ability to continuously adjust parameters based on the actual performance of the system at any given time.

Fig.5 shows an adaptive controller, which is a controller with adjustable parameters and a mechanism for adjusting the parameters in a way which optimizes a measured property of the system.

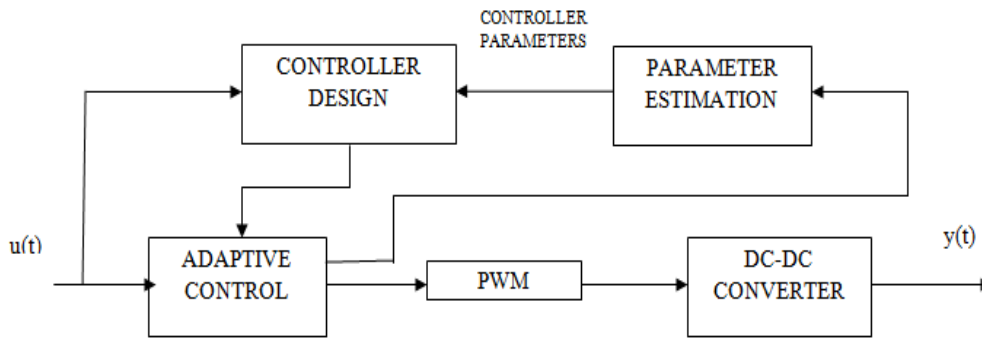


Fig.5 Adaptive Control Based DC-DC Converter

Fig.5 shows an adaptive controller in which the parameters of the plant are estimated by the ‘plant parameter estimation’ block and the controller is designed by the ‘controller design’ block to meet some pre-determined requirements such as closed loop bandwidth. Using such an arrangement, optimized transient response can be achieved over a wide range of power stage component values and conditions, with the closed loop bandwidth maintained automatically.

VIII. SLIDING MODE CONTROL BASED DC-DC CONVERTER

SM controller is a type of non-linear controller. It is employed and adopted for controlling variable structured systems (VSSs). It is very easy to implement as compared to other types of nonlinear and classical controllers. Two important steps in SM control is to design a sliding surface in state space and then prepared a control law to direct the system state trajectory starting from any arbitrary initial state to reach the sliding surface in finite time, and at the end it should arrive to a point where the system equilibrium state exists that is in the origin point of the phase plane. There are three important factors responsible for the stability of SM controllers, existence, stability, and hitting condition. The sliding line divides the phase plane into two main regions. Each region is represent by a switching state and when the trajectory comes at the system equilibrium point, in this case the system is considered as stable system.

Fig.6 shows a unique feature of an ideal sliding mode control technique is that it operates at infinite switching frequency. But practical SM controllers are operated at finite switching frequencies represent a quasi-sliding mode.

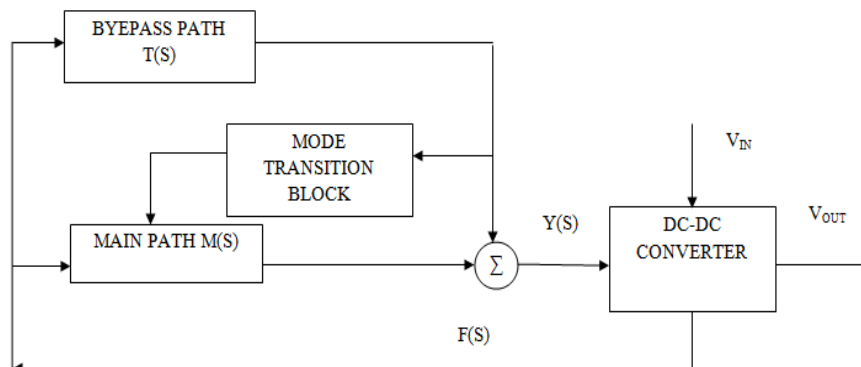


Fig.6 Sliding Mode Control Based DC-DC Converter

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IX. ARTIFICIAL NEURAL NETWORK BASED DC-DC CONVERTER

The artificial neural networks (ANN) can be designed without the exact model of the converter. This approach of ANN design guarantees the stable operation even if there is a change in the converter parameters. For ANN, it is sufficient to understand the general behaviour of the system. Artificial neural systems can be defined as cellular systems which have the capability of acquiring, storing, and utilizing experiential knowledge. The ANN controllers are the optimal control that permits to obtain an optimal model of the converter. Thus the main reason of using neural networks (ANN) is due to their ability to approach any function, either linear or not.

Fig.7 shows the general block diagram of ANN based DC-DC converter. The ANN model is trained by different different algorithms depending on the applications.

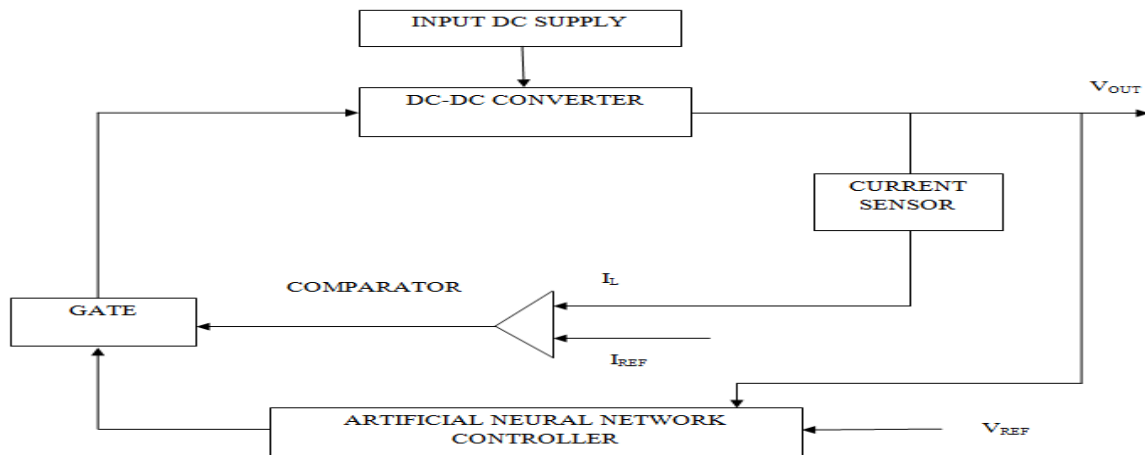


Fig.7 ANN Based DC-DC Converter

X. FUZZY LOGIC CONTROL BASED DC-DC CONVERTER

A completely different approach is offered by the Fuzzy Logic Control (FLC), which does neither require a precise mathematical modeling of the system nor complex computations. This control technique relies on the human capability to understand systems behaviour, and is based on qualitative control rules. Thus, control design is simple, since it is only based on linguistic rules of the type: "if the output voltage error is positive and its rate of change is negative then reduces slightly the duty-cycle", and so on. This approach lies on the basic physical properties of the systems and it is potentially able to extend control capability even to those operating conditions where linear control techniques fail in large-signal dynamics and large parameter variations. Of course, fuzzy controllers cannot provide, in general, better small-signal response than standard regulators.

Fig.8 shows that fuzzy control is based on heuristic rules and it makes easy application of non-linear control laws to face the non-linear nature of DC-DC converters.

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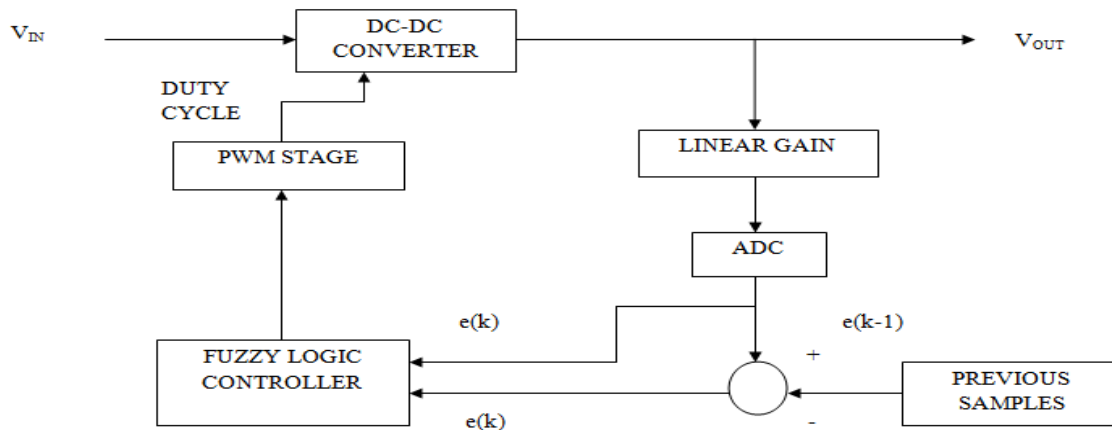


Fig.8 FLC Based DC-DC Converter

XI. COMPARISON RESULTS

The Table.1 gives the efficiency of various control techniques in DC-DC converters. The efficiency of each method is been tabulated. But this efficiency not only depends on the control techniques but also on the design specifications of the DC-DC converters.

Table.1 Efficiency of various Control Techniques in DC-DC Converters

S.No	Type of DC-DC Converter	Efficiency (%)
1	Current Mode Control	87
2	Voltage Mode Control	94.13
3	PID Control	95
4	MPC Control	96.3
5	Adaptive Control	96
6	Sliding Mode Control	97.5
7	ANN Control	98
8	Fuzzy Logic Control	98.4

XII. CONCLUSION

In this paper the various control techniques implemented for DC-DC converters and the efficiency are discussed. The efficiency of various control techniques varies with respect to the design components of the DC-DC converters. Each control techniques have their own benefits and drawbacks. It is based on the application for which the control mechanisms can be implemented. At present the ANN and Fuzzy Logic Controllers are being widely used due to wider range of operating conditions. Furthermore, the performance of the converters can be improved by Neuro-Fuzzy Controllers with various optimisation techniques.

REFERENCES

- [1] Abilio Parriera, Floriberto Lima and Marcelino Santos, " Digital Modular Control of High Frequency DC-DC Converters", Microelectronics Journal, Vol.45, pp. 1254-1260, 2014.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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- [2] Esmaeil Mirzaei and Esmaeil Mirzaei, "Auto Tuning PID Controller Using Chaotic PSO Algorithm for a Boost Converter", 13th Iranian Conference on Fuzzy Systems (IFSC), 2013.
- [3] Hussain K. Sayed, "Modeling and Control of a Buck DC-DC Converter Based on Artificial Neural Network", International Journal of Scientific & Engineering Research, Vol.4, No.11, pp. 1224-1233, 2013.
- [4] Meriem Nachidi, Ahmed El Hajjaji and Jérôme Bosche, "An enhanced control approach for DC-DC converters", Electrical Power and Energy Systems, Vol.45, pp.404-412, 2013.
- [5] Pierre Petit, Michel Aillerie, Jean-Paul Sawicki and Jean-Pierre Charles, "High efficiency DC-DC converters including a performed recovering leakage energy switch", Energy Procedia, Vol.36, pp.642-649, 2013.
- [6] H. Kawashima, Y. Wardi, D. Taylor, and M. Egerstedt, "Optimal Switching Control of a Step-Down DC-DC Converter", American Control Conference, 2012.
- [7] Kashif Ishaque, Zainal Salam, Muhammad Amjad, and Saad Mekhilef, "An Improved Particle Swarm Optimization (PSO)-Based MPPT for PV With Reduced Steady-State Oscillation", IEEE Transactions on Power Electronics, Vol.27, No.8, pp.3627-3637, 2012.
- [8] Kumars Roubzbehii, Arash Miranian, Costantino Citro, Alvaro Luna and Pedro Rodriguez, "Enhanced Average Current-Mode Control for DC-DC Converters Based on an Optimized Fuzzy Logic Controller", 2012.
- [9] Ahmad El Khateb, Nasrudin Abdul Rahim and Jeyraj Selvaraj, "Optimized PID Controller for Both Single Phase Inverter and MPPT SEPIC DC/DC Converter of PV Module", IEEE International Electric Machines & Drives Conference (IEMDC), 2011.
- [10] Sungwoo Lee, Seungchul Jung, Jin Huh, Changbyung Park, Chun-Taek Rim and Gyu-Hyeong Cho, "Robust and Efficient Synchronous Buck Converter with Near-Optimal Dead-Time Control", ISSCC, 2011.
- [11] U. Ribes-Mallada, R. Leyva, and P. Garces, "Optimization of DC-DC Converters via Geometric Programming", Mathematical Problems in Engineering, Vol.2011, pp.1-19, 2011.
- [12] Yao Yao, Fidegnon Fassinou and Tingshu Hu, "Stability and Robust Regulation of Battery-Driven Boost Converter With Simple Feedback", IEEE Transactions on Power Electronics, Vol.26, No.9, pp.2614-2626, 2011.
- [13] Yong-Saeng Shin, Sung-Soo Hong, Dong-Joong Kim, Dong-Sung Oh and Sang-Kyoo Han, "A New Mode Changeable Full Bridge DC-DC Converter for Wide Input Voltage Range", 8th International Conference on Power Electronics - ECCE Asia, 2011.
- [14] Carlos Andres Torres-Pinzon and Ramon Leyva, "Fuzzy Control in DC-DC Converters: an LMI Approach", 2010.
- [15] Kapat S. and Krein P.T., "PID controller tuning in a DC-DC converter: A geometric approach for minimum transient recovery time", Control and Modeling for Power Electronics (COMPEL), IEEE 12th Workshop, pp.1-6, 2010.
- [16] Liu Shulin and Ma Yibo, "Optimization Design of the Inductance of Boost Converters", International Conference on Electrical and Control Engineering, 2010.
- [17] Ren-Xi Gong, Ling-Ling Xie, Kuang Wang and Cun-Dai Ning, "A Novel Modeling Method of Nonideal Buck-Boost Converter in DCM", 3rd International Conference on Information and Computing, 2010.
- [18] Shamim-Ul-Alam.M, Quamruzzaman.M and Rahman.K.M, Fuzzy logic based sliding mode controlled DC-DC boost converter, International Conference on Electrical and Computer Engineering(ICECE), pp.70-73, 2010.
- [19] Sang Hee Kang, Hien Nguyen, Dragan Maksimovic and Isaac Cohen, "Efficiency Characterization and Optimization in Flyback DC-DC Converters", 2010.
- [20] Thiago Soeiro, Jurgen Biela, Jonas Muhlethaler, Jorgen Linner, Per Ranstad and Johann W. Kolar, "Optimal Design of Resonant Converter for Electrostatic Precipitators", International Power Electronics Conference, 2010.
- [21] Tomas Reiter, Dieter Polenov and Hartmut Probstle, "PWM Dead Time Optimization Method for Automotive Multiphase DC-DC Converters", IEEE Transactions On Power Electronics, Vol.25, No.6., pp.1604-1614, 2010.
- [22] U. Badstuebner, J. Biela, and J.W. Kolar, "Design of an 99%-Efficient, 5kW, Phase-Shift PWM DC-DC Converter for Telecom Applications", 2010.
- [23] Ya-Ting Lee, Chian-Song Chiu and Chih-Teng Shen, "Adaptive Fuzzy Terminal Sliding Mode Control of DC-DC Buck Converters via PSoC", IEEE International Conference on Control Applications, 2010.
- [24] Ayaz Hasan and Stefano Gregori, "Modeling of Step-Up DC-DC Converters to Formulate Design Guidelines for Optimization", 2009.
- [25] Francesco Amato, Carlo Cosentino, Antonino S. Fiorillo and Alessio Merola, "Stabilization of Bilinear Systems Via Linear State-Feedback Control", IEEE Transactions on Circuits and Systems, Vol.56, No.1, pp.76-80, 2009.
- [26] Kinattungal Sundareswaran and V. T. Sreedevi, "Boost Converter Controller Design using Queen-Bee-Assisted GA", IEEE Transactions On Industrial Electronics, Vol.56, No.3, pp.778-783, 2009.
- [27] Rais Miftakhutdinov, "Power Saving Solutions in DC/DC Converter for Data and Telecommunication Power System", PEDS, 2009.
- [28] S. Mariethoz, S. Almer and M.Morari, "Optimal control of a two control input buck-boost converter", 48th IEEE Conference on Decision and Control, 2009.
- [29] Yungtaek Jang, Milan M. Jovanovic and David L. Dillman, "Light-Load Efficiency Optimization Method", 2009.
- [30] A.Dell Aquila and A. Lecci, "PSO-based Control Optimization of Power Converters", International Symposium on Power Electronics, Electrical Drives, Automation and Motion, 2008.
- [31] Michael D. Seeman and Seth R. Sanders, "Analysis and Optimization of Switched-Capacitor DC-DC Converters", IEEE Transactions On Power Electronics, Vol.23, No.2, pp.841-850, 2008.
- [32] Olivier Trescases, Guowen Wei, Aleksandar Prodic and Wai Tung Ng, "Predictive Efficiency Optimization for DC-DC Converters With Highly Dynamic Digital Loads", IEEE Transactions on Power Electronics, Vol.23, No.4, pp.1859-1868, 2008.
- [33] Saggini.S, Mattavelli.P, Ghioni. M and Redaelli. M, "Mixed-Signal Voltage-Mode Control for DCand#x2013;DC Converters With Inherent Analog Derivative Action", IEEE transactions on Power Electronics, Vol.23, pp.1485-1493, 2008.
- [34] Abdelhalim Kessal and Lazhar Rahmani, "Ga-Optimized Parameters of Sliding-Mode Controller Based on Both Output voltage and Input Current with an Application in the PFC of AC/DC Converters", IEEE Transactions on Power Electronics, Vol.29, No.6, pp.3159-3165, 2007.
- [35] Andreas Wernrud, "Strategies for Computing Switching Feedback Controllers", Proceedings of the 2007 American Control Conference, 2007.
- [36] Chen Bing, Xie Yun-Xiang, Huang Feng and Chen Jiang-Hui, "A Novel Single-phase Buck PFC Converter Based on One-cycle Control", Electric Power College, South China University of Technology, Guangzhou, China, 2006.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

- [37] He. Y and Luo. F.L, "Sliding-mode control for DC-DC converters with constant switching frequency, Control Theory and Applications", IEE Proceedings, Vol.153, pp. 37-45, 2006.
- [38] Jaber A. Abu Qahouq, Wisam Al-Hoor, Liangbin Yao and Issa Batarseh, "Drive Voltage Optimization Controller To Improve Efficiency", University of Central Florida, Florida, USA, 2006.
- [39] Jifeng Han, Annette von Jouanne and Gabor C. Temes , "A New Approach to Reducing Output Ripple in Switched-Capacitor-Based Step-Down DC-DC Converters ",IEEE Transactions on Power Electronics, Vol.21, No.6, pp. 1548-1555, 2006.
- [40] Trescases. O, Lukic. Z, Wai-Tung. N and Prodic. A, " A low-power mixed-signal current-mode DC-DC converter using a one-bit and Delta; and Sigma; DAC", Applied Power Electronics Conference and Exposition(APEC),Vol.5,2006.

BIOGRAPHIES



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