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Comparison of Transient Responses of Two Switch forward converter with sliding mode controller and HC-Fuzzy controller

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ABSTRACT

Two switch forward converters with slide mode controller are compared with HC-fuzzy controller. The performance of the work is to foster and promote unbiased and accurate comparison of sliding mode controller and HC-Fuzzy controller. Sliding mode controller and HC-Fuzzy controller are designed to control the speed time invariant model of a DC motor. The output of the converter controlled by controller applied to the nominal DC motor and is presented. A general-purpose sliding-mode controller and HC fuzzy controller are applied to two switch forward DC/DC converter topology. HC fuzzy controller provides extreme robustness and speed of response against biasing, load and parameter variations. HC- fuzzy controller can be a useful tool for the control Engineer. Moreover the proposed solution features are constant switching frequency in the steady state, synchronization to external triggers, and reduced steady-state errors in the output voltage.

Keywords: DC-DC converter, Interleaved-forward-converter, Matlab-simulink, sliding mode controller, HC-Fuzzy controller and DC motor

1. INTRODUCTION

An industrial and some commercial applications need DC power. An Electronic DC Converter that transforms Direct Current from low/high level to another. With isolated DC converters, level of DC voltage is changed to another level by exchanging the input for the time being and delivering that energy to the output at a various voltage level. Majorly these converters are used in easily movable electronic gadgets like computers and cellular phones which are provided with power from batteries. Forward- converter (FC) is an admired SMPS circuit that is widely used in fabricating isolated and controlled DC output from the uncontrolled DC input power. Some of the applications of these forward- converters (FC) are supply power for DCM, Electric vehicle, Telecommunication applications, Battery charging etc.

In control framework, sliding mode control (SMC) is a nonlinear control technique that modifies the elements of a nonlinear framework by applying an irregular control sign or all the more thoroughly, a set-esteemed control signal that power the framework to "slide" along a cross-segment of the frameworks. Consequently, sliding mode control is a variable control technique. All things being equal, it will be sliding along the limits of the control structures. The movement of the framework as it slides along these limits is known as a sliding mode and the mathematical locus comprising of the limits is known as the sliding (hyper) surface [1-3]. The sliding mode controller was tested with forward DC/DC converter topologies.

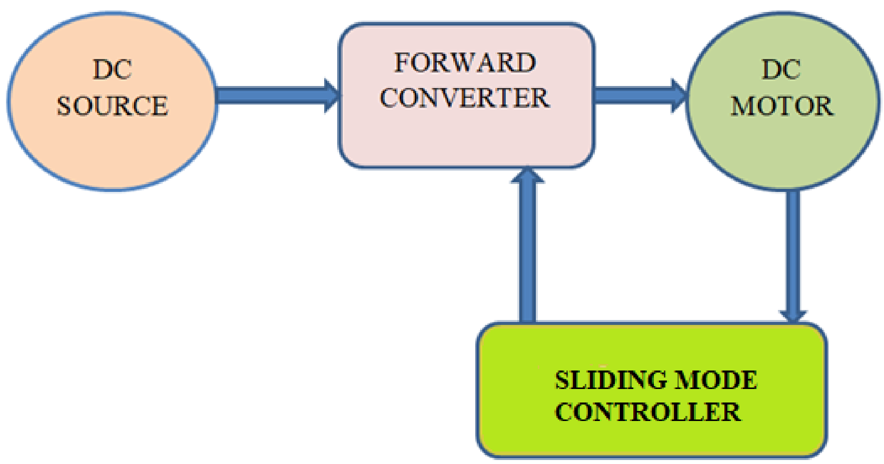

Fig 1.1 Forward converter with sliding mode controller

Hysteretic control based fuzzy logic controller, which does neither require an exact numerical displaying of the framework nor compels calculation. This control procedure depends on the human capacity to grasp frameworks' way of behaving, and depends on subjective control rules. This approach lies on the fundamental actual properties of the frameworks and it is possibly ready to stretch out control ability even to those working circumstances where direct control methods fall flat, for example huge sign elements and enormous boundary varieties. Obviously, fuzzy regulators can't give, as a general rule, preferred little sign reaction over standard controllers. Be that as it may, since fuzzy control depends on heuristic principles, it makes simple utilization of non-direct control regulations to confront the non-straight nature of DC/DC converters. The HC-Fuzzy approach is general, as in practically a similar control rules can be applied to a few DC/DC converters; in any case, some scale factors should be tuned by converter characteristics and boundaries [4-8]. The proposed HC-Fuzzy controller was tried on forward converter. Simulated results are tabulated.

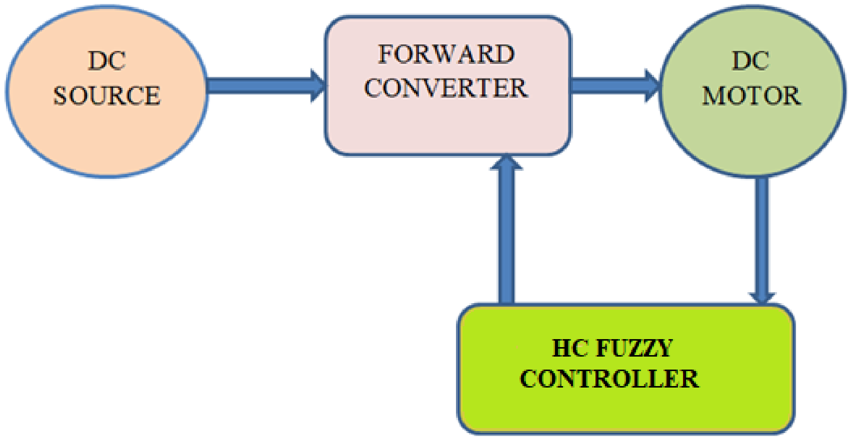

Fig 1.2 Forward converter with HC Fuzzy controller

2. RELATED WORK

Sliding mode control is to involve a sliding surface as a kind of perspective way to such an extent that path of the controlled state factors generally moves towards the close by locale with an alternate control structure. The development of the framework as it crawls along the edge of these limits is depicted as sliding mode and the mathematical locus comprising of the limits is known as the sliding surface. This can be accomplished by fulfilling the hitting, presence and soundness conditions and by expecting limitless exchanging recurrence for the framework activity. Hitting condition ensures that regardless of starting circumstances, state direction of the framework will constantly be coordinated towards the sliding surface. Presence condition ensures that state factors stay in the sliding plane and soundness condition makes framework to arrive at stable balance point while working under SM controlled DC/DC converter [1-3].

Yaxiao et al (2020) planned high-voltage-gain DC to DC converters for high current applications. The converter is gotten from the half and half combination of a changed capacitor converter and a stage around converter. This prompts high move forward voltage transformation proportion with non-throbbing current, low voltage weight on the switches as a whole, basic execution of control and driving circuits, versatility for high current high-power applications and minimal expense because of less parts. Full delicate charging activity and less gadget voltage stresses are achieved under all working circumstances. Consistent state activities of the great voltage gain DC to DC converter are methodically investigated.

Hamed et al (2020) proposed regulator for DC to DC converter taking care of steady power load in a DC microgrid. The negative impedance normal for the consistent power loads (CPLs) makes shakiness in DC converters in the DC microgrids. To work on the security of the DC to DC converter taking care of CPLs, a hearty and quick regulator is required. The powerful heartbeat width balance based type-II fluffy regulator for a DC to DC converter taking care of the CPL in a DC microgrid is dissected hypothetical and continuous recreation are introduced to exhibit the viability of the non-number shrewd regulator.

Keon et al (2020) proposed high effectiveness DC to DC converter with decreased coursing current and rectifier voltage stress by involving coupled inductor in the rectifier circuit. Because of diminished flowing current, the conduction misfortune in the essential side circuit is limited. Moreover, the conduction loss of rectifier diodes is additionally diminished. Subsequently, the effectiveness can be worked on because of the abatement in conduction misfortunes in the essential circuit and rectifier diodes. The attributes of the proposed converter are investigated and contrasted and different converters.

Enhui Chu et al (2020) planned an interleaved two-change forward DC to DC converter with zero-voltage and zero-current exchanging, which as a coupled inductor and a capacitor. The proposed converter can accomplishes delicate activity for principal power switches by utilizing the coupled inductor and capacitance. Contrasting and the underlying converter that utilizes a coupled inductor, during the freewheeling stage, the proposed converter has critical execution in decreasing the essential coursing current that moves through the power components. All the more conspicuously, the proposed converter can take out the issues in the correction diodes. In light of the same circuits in various activity modes, the activity guideline and the delicate exchanging necessity of the converter are examined.

Saman et al (2019) examined about geographies and control plans for Bidirectional DC to DC power converters. DC to DC converters are logically utilized in different applications by which power stream in both forward and turn around headings is required. These incorporate energy stockpiling frameworks, uninterruptable power supplies, electric vehicles and environmentally friendly power frameworks. Moreover, the normal control plans and it are likewise assessed to switch techniques for different converters. A portion of the control plans are normally applied to all DC to DC power converters like PID, sliding mode, fluffy, model prescient, computerized control, and so forth. Some exchanging systems were planned for secluded bidirectional DC to DC converters to propel their presentation. The highlights of every geography and control plot alongside their run of the mill applications are examined.

3. PROBLEM STATEMENT

The vast majority of the above research works are engaged in open control for different DC converters. FC isn't constrained by a regulator and the result is left unregulated. Additionally, the FC isn't worked with complex control strategies to control the result boundaries.

The FC moves energy immediately across the transformer and doesn't depend on energy capacity in components which prompts better usage of transformer. The result inductor and diode keep the result current genuinely steady and the auxiliary wave current is decisively decreased. The FC gives low result voltage wave and supports numerous results.

In this work, relative necessary regulator, hysteretic regulator and fluffy rationale regulator based TWSFC is modeled.

4. FORWARD- CONVERTER

A TWSFC is depicted in Figure 4.1. The two n-channel MOSFETs M1 and M2 connected at the source side. The four diodes at the transformer secondary act as rectifier denoted by D1, D2, D3 and D4 respectively. Vdc is input supply and RL represents the load resistance.

The switching period is represented by Ts, which is the reciprocal of the switching frequency fs. The duty-ratio is the fraction of the ON time (TON) to the total time Ts (Ting 2017). The input voltage is divided equally by using two capacitors C1 and C2 and DC is converted into high-frequency AC by using two switches M1 and M2.
The converted AC is stepped down through transformers T1 and T2 and again converted into controlled DC using a rectifier. Inductor L allows constant current flow through the load and capacitor C at the output acts as filter. The TWSFC uses an inductor, a capacitor and two diodes and is known as snubber circuit. When the switches are on, the main power forwarding and when the switch is off, a diode and a capacitor clamp the drain-source voltage. Reset of the capacitors accomplished through a LC resonance formed by L, C and D5, D6. Transformer reset is achieved through the body diode of MOSFET.

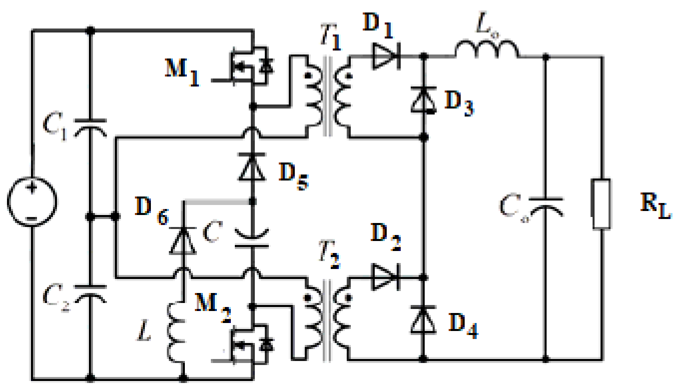

Figure 4.1 Basic Circuit of TWSFC

5. SIMULATION OF TWO SWITCH FORWARD CONVERTER WITH SLIDING MODE CONTROLLER

The circuit is designed using the elements of MATLAB simulink. Interleaved two switch forward converter using sliding mode controller is shown in Fig 5.1. The energy from upper capacitor is discharged to transformer T_1 and lower capacitor energy is transferred to transformer T_2. These two transformers stepdown the voltage and an uncontrolled rectifier is used to rectify the secondary voltage. The motor is controlled to run at constant speed of 300RPM.

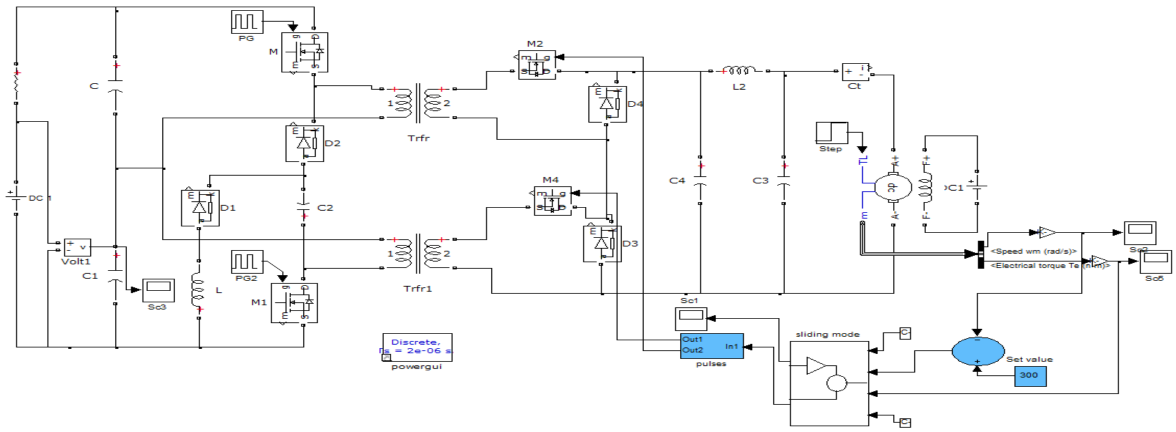

Fig 5.1 Simulation of two switch forward converter using sliding mode controller

The input voltage to interleaved two switch forward converter using sliding mode controller is 300 Volts shown in fig 5.2. Fig 5.3 shows output voltage which is equal to 48 Volts. The waveform of Output current is shown in Fig 5.4. Fig 5.5 and 5.6 shows motor speed and motor torque respectively.

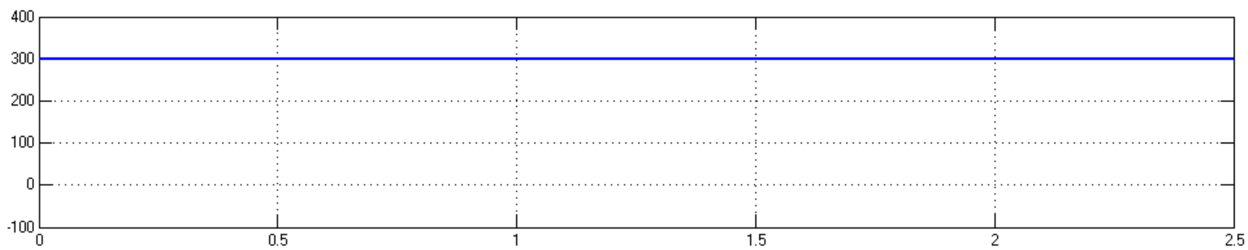

Fig 5.2 Input voltage waveform

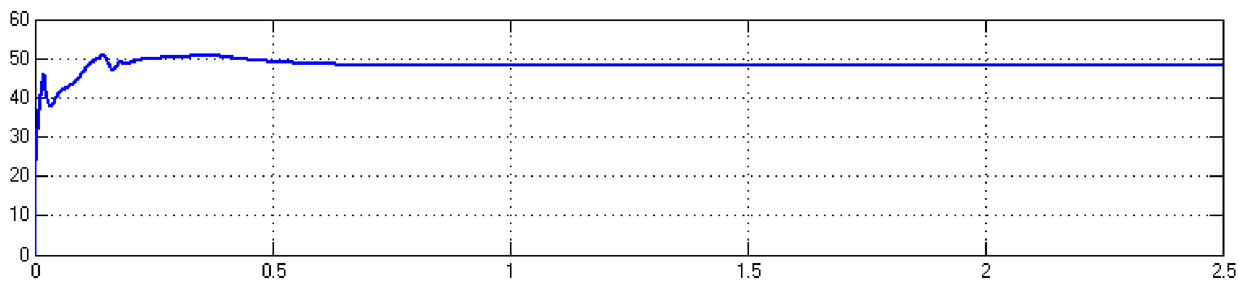

Fig 5.3 Output voltage waveform

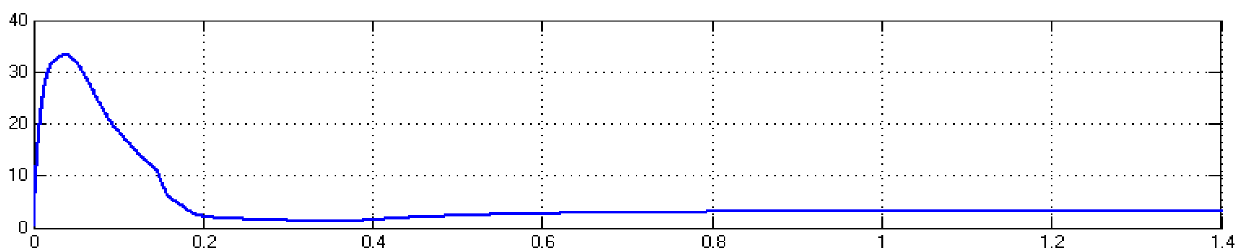

Fig 5.4 Output current waveform

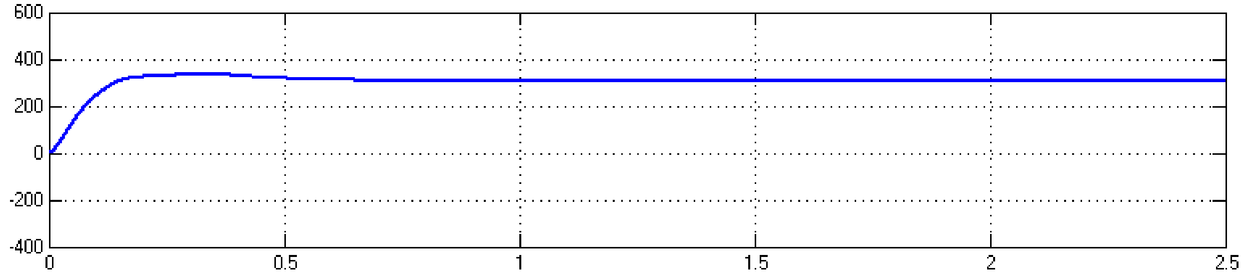

Fig 5.5 Speed of motor

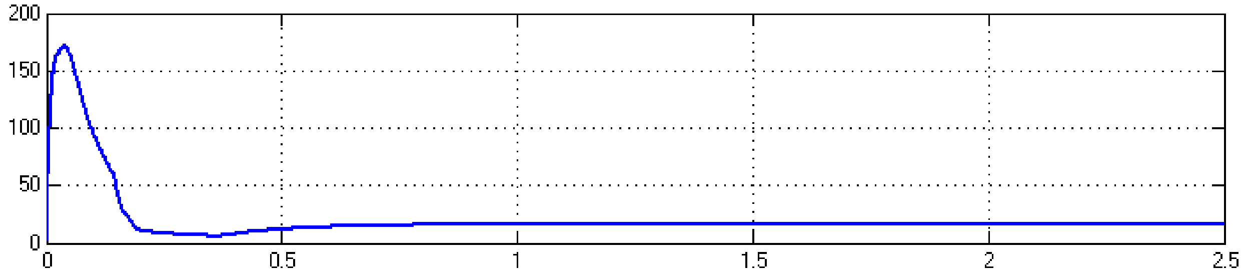

Fig 5.6 Motor Torque

6. SIMULATION OF TWO SWITCH FORWARD CONVERTER WITH HC FUZZY CONTROLLER

Fig 6.1 shows the model simulink for two switch converter with HC fuzzy controller. Output voltage waveform, output current waveform and output power waveform are measured using scopes. Transformer secondaries are aided and eneries saved in the π filter and then it is transferred to the load.

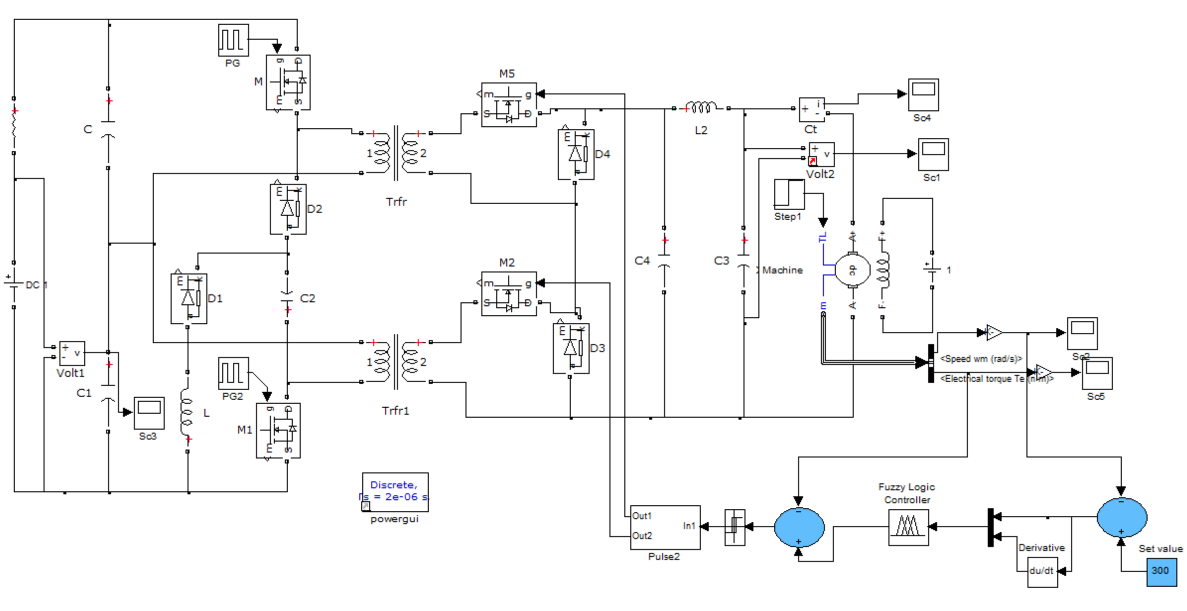

Fig 6.1 Three switch forward converter using resistive load

The input voltage to interleaved two switch forward converter using HC fuzzy controller is 300 Volts shown in fig 6.2. Fig 6.3 shows output voltage. The waveform of Output current is shown in Fig 6.4. Fig 6.5 and 6.6 shows motor speed and motor torque respectively.

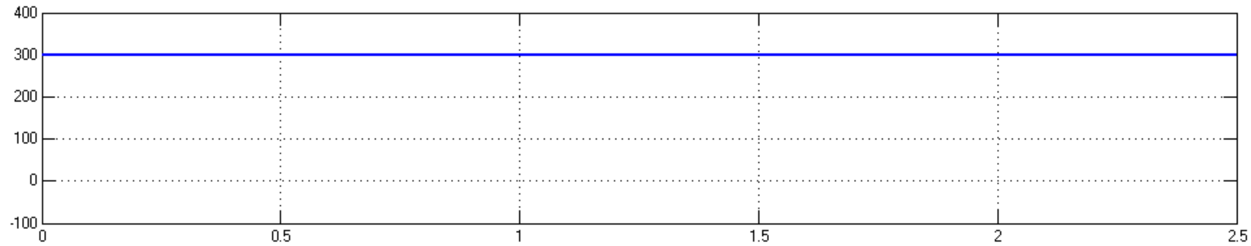

Fig 6.2 Input voltage waveform

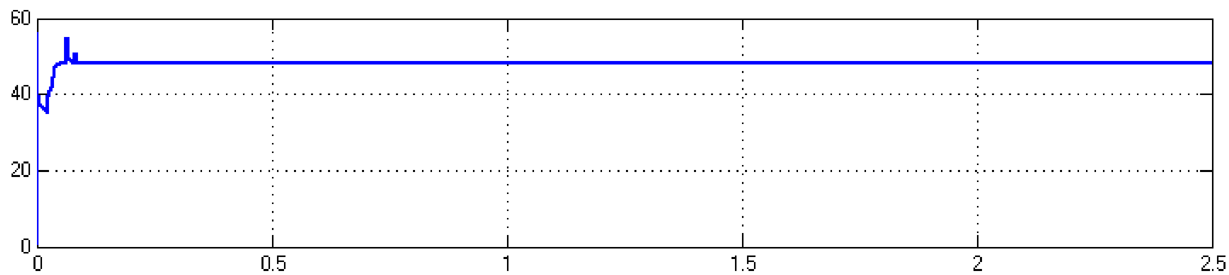

Fig 6.3 Output voltage waveform

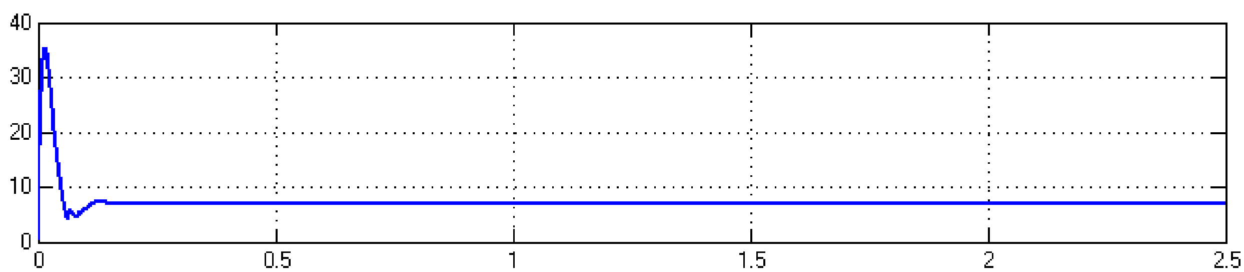

Fig 6.4 Output current waveform

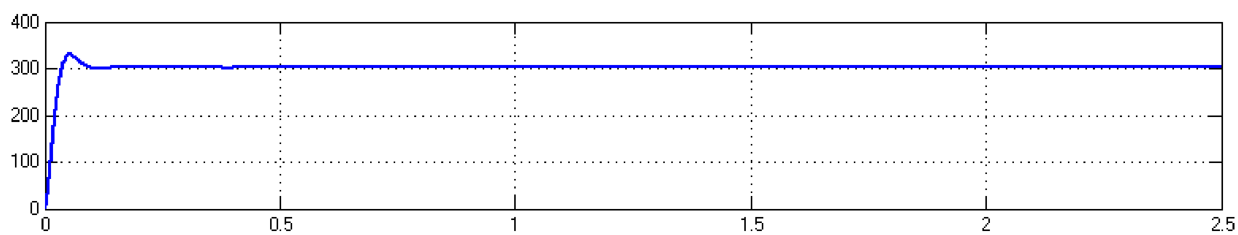

Fig 6.5 Speed of motor

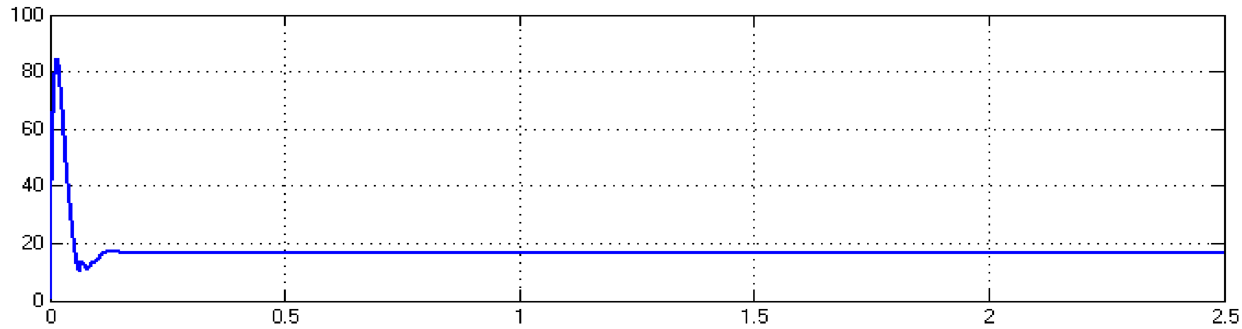

Fig 6.6 Motor Torque

7. COMPARTIVE RESULTS

7.1 Comparison Between motor speed waveforms using Sliding Mode Controller and HC-Fuzzy Controller

Rise time, Peak time, Settling time and Steady state error two switch forward converter with sliding mode controller and HC-fuzzy controller is listed in the table 1. While comparing, the speed waveform of dc motor using HC -fuzzy controller have better result than sliding mode controller.

Controller	Rise time (s)	Peak time (s)	Settling time (s)	Steady state error (rpm)
SMC	0.28	0.36	0.70	0.5
HC-FLC	0.05	0.06	0.16	0.06

Table 1 Comparison of time domain parameters for motor speed

7.2 Comparison Between motor torque waveforms using Sliding Mode Controller and HC-Fuzzy Controller

Rise time, Peak time, Settling time and Steady state error two switch forward converter with sliding mode controller and HC-fuzzy controller is listed in the table 2. While comparing, the torque waveform of dc motor using HC-fuzzy controller have better result than sliding mode controller.

Controller	Rise time (s)	Peak time (s)	Settling time (s)	Steady state error (N-m)
SMC	0.06	0.07	0.75	0.3
HC-FLC	0.008	0.01	0.14	0.05

Table 2 Comparison of time domain parameters for motor Torque

CONCLUSION

Two switch serial- input forward -a converter with DC motor load is simulated using MATLAB Simulink. The results of two switch forward converter with sliding mode controller and HC-Fuzzy controller are compared. The output of HC-Fuzzy controller is better than that of sliding mode controller. The simulation study results confirmed the advantages of SMC and HC-Fuzzy controller performance against speed- torque characteristics of the drive. The time response of the speed waveform using HC-Fuzzy controller has performed better than SMC controller with the settling-time of 0.16 sec and steady-state error has 0.06 RPM

REFERENCES

1. B.Kiran, P.Parthiban, Debashisha.Jena And P.S.Prakash "Design And Implementation Of Sliding Mode Voltage Controller For Dc To Dc Buck Converter By Using Hysteresis Modulation And Pulse Width Modulation" Biennial International Conference On Power And Energy Systems: Towards Sustainable Energy (Pestse), 2016, Pp-1-6

2. Anju et al Sliding Mode Controlled Forward Converter IEEE Sponsored 9th International Conference on Intelligent Systems and Control (ISCO)2015

3. V. S. C. Raviraj And P. C. Sen, "Comparative Study Of Proportional– Integral, Sliding Mode, And Fuzzy Logic Controllers For Power Converters" In 1997 Ieee Transactions On Industry Applications, Vol. 33, No. 2, March/April 1997, 0093–9994/97

4.Chetan P. Ugale And Dr. V. V. Dixit "Buck-Boost Converter Using Fuzzy Logic For Low Voltage Solar Energy Harvesting Application" 11th International Conference On Intelligent Systems And Control (Isco), 2017, Pp.413-417

5. Guang Feng And Wanfeng Zhang "An Adaptive Current Mode Fuzzy Logic Controller For Dc-To-Dc Converters" Ieee, 2003, Pp-983-989

6.K. Viswanathadn, Srinivasarn And Orucan "A Universal Fuzzy Controller For A Non-Linear Power Electronic Converter" In 2002 Ieee 0-7803-7280-8/02

7. Wing-Chi So, Chi K. Tse And Yim-Shu Lee "Development Of A Fuzzy Logic Controller For Dc/Dc Converters: Design, Computer Simulation, And Experimental Evaluation" In 1996 Ieee Transactions On Power Electronics, Vdl 11, No. 1, January 1996, 0885-8993/96

8.B. Hariharasubramaniam And M. Preethi Pauline Mary "Comparison Of Pi And Flc For Ac/Dc Converter Using Sepic In Renewable Energy System" In August 2015 Indian Journal Of Science And Technology, Vol 8(17).

9. J. Taotao,et al, "A New Interleaved Series Input, Parallel Output Forward -Converter with Demagnetizing Features," IEEE Trans. Power Electr., vol. 23, no. 2, pp. 888–895, Mar. 2008

10.Yaxiao Qin, Yun Yang and Sinan Li (2020)" A High efficiency DC/DC converter for high voltage gain high current applications"., IEEE Transactions on Power Electronics, Vol. 8, No. 3, pp. 2812 – 2823.

11.Keon-Woo Kim, Jung-Kyu Han, Byoung-Hee Lee and Gun-Woo Moon (2020) "High efficiency three-level DC-DC converter with reduced circulating current and rectifier voltage stress"., IEEE Transactions on Power Electronics, Vol 35, No: 3, pp 2668 – 2679.

12.Hamed Farsizadeh and Meysam Gheisarnejad (2020) "An Intelligent and Fast Controller for DC/DC Converter Feeding CPL in a DC Microgrid"., IEEE Transactions on Circuits and Systems, Vol. 67, No.6, pp 1104 – 1108.

13.Saman A. Gorji, Hosein G. Sahebi, Mehran Ektesabi and Ahmad B. Rad "Topologies and control schemes of bidirectional DC–DC power converters: An overview" IEEE Access- Advanced energy storage technologies and their applications , Vol. 7, pp 117997 – 118019.

14.Enhui Chu, Jianqun Bao, Haolin Xie and Guotao Hui (2020) "A Zero-Voltage and Zero-Current Switching Interleaved Two-Switch Forward Converter with Passive Auxiliary Resonant Circuit"., IEEE Transactions on Power Electronics, Vol., 35, No. 5, pp 4859-4876.