KY Converter Fed Dc Motor For Low Power Application

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Abstract. This paper aims to design and to simulate a various DC-DC Converter with closed loop control. DC-DC converter is electronic co converter converts direct current source from one voltage to the level voltage. It is a type of electric power converter. The range of power vary from very low to very high. MATLAB Simulink has been used in modelling and simulation of the circuits. We have analysed the closed loop control of various DC-DC converters like buck, boost, buck-boost and KY converters using MATLAB Simulink. The KY converter is chose for the low power application and the same was designed and simulated.

1.Introduction

Portable electronic devices using DC-DC converters, such as cell phones and laptops, are primarily powered by batteries. These electronic devices often contain multiple sub-circuits, each with its own voltage level requirements that differ from those supplied by the battery or external power source. Also, the battery voltage decreases as the stored energy is depleted. To increase voltage from a partially lowered battery voltage the switched DC to DC converters offer a method by saving space instead of using multiple batteries to accomplish the same thing. KY converter, a voltage boosting converter is proposed to operate in continuous conduction mode (CCM).It has the advantages of no ripple current, low output ripple and good load transient response. Solar panels are used to provide DC power and batteries store this DC voltage. The KY converter is provided with the voltage stored in the battery for boosting its voltage level. The output of the converter circuit KY is then sent directly to the load. It produces a continuous output with a reduced number of ripples.[1,2]

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Through Simulation the voltage mode control is tested by tuning a PID controller, and its operation is tested. The industries have been using Proportional-Integral-Derivative (PID) controllers for several decades for process control applications. PID involves three separate parameters, the proportional, the integral and derivatives. By defining three constants in the PID controller algorithm, the controller can provide control actions designed for specific process requirements. In a PID controller implemented in a closed-loop system, the tracking error, the difference between the desired input value and the actual output, is represented by a variable. The PID controller receives this error signal and the controller calculates the derivative and the integral of this error signal. The signal that has just passed through the controller is now equal to the proportional gain multiplied by the magnitude of the error plus the integral gain multiplied by the integral of the error plus the derivative gain multiplied by the derivative of the error which will be sent to the device and the new output will be obtained. The new error signal would be generated when the former output is fed back to the sensor. The duty cycle of the PWM signal applied to the semiconductor switch and MOSFET is controlled by the PID controller as per the output requirement. The input voltage is taken as 36V. With the reference voltage the operation of the converters can be best verified. It has been shown by the results that the designed PID controller has better output voltage tracking ability, thus improving output voltage regulation.

The controller exhibits a better output voltage tracking with minimal overshoot, small steady state error, shorter settling time, and higher converter efficiency.[3,4]

2. Analysis of various DC-DC Converters

2.1. Buck Converter

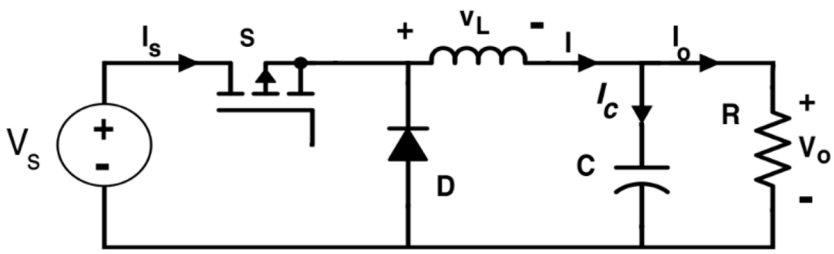

Figure 1. Buck Converter

The fig.1 shows the circuit diagram of Buck converter. When the switch is turned ON, diode will be in OFF. The source current flows will be equal to inductor current and the charging of inductor takes place. When the switch is turned OFF the diode starts connecting and the inductor acts as source and it discharge.[5]

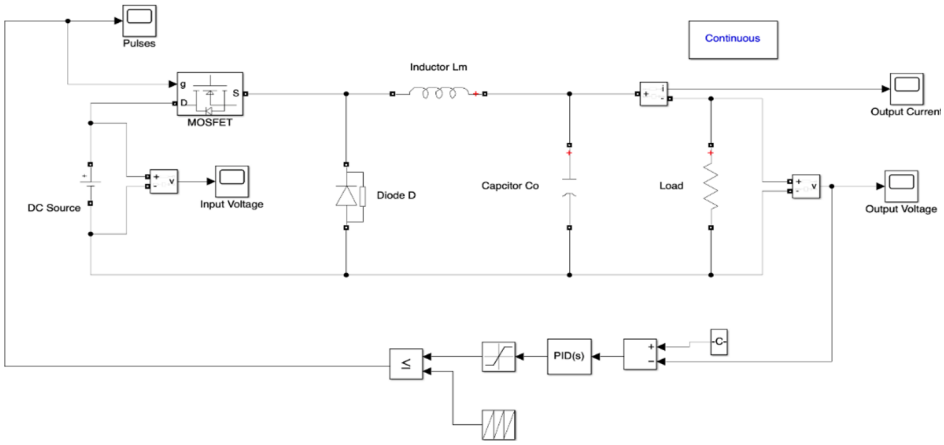

Figure 2. Simulation Model of Buck Converter

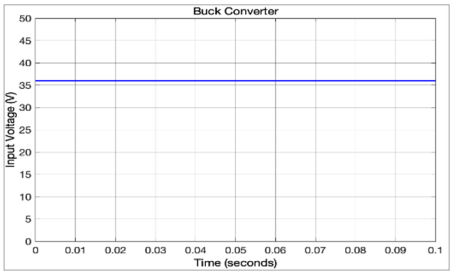

Figure 3. (a) Buck Converter - Input

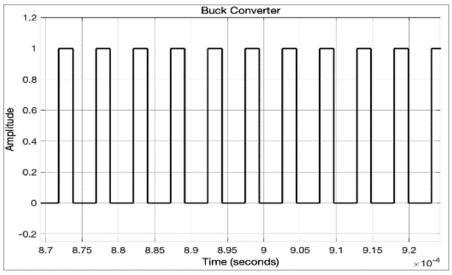

Figure 3. (b) Buck Converter -Pulses

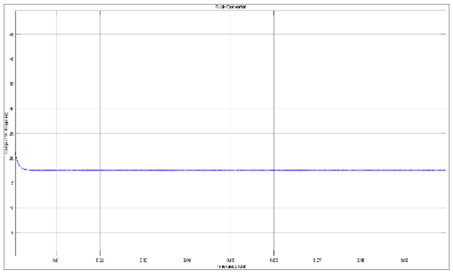

Figure 3. (c) Buck Converter - Output

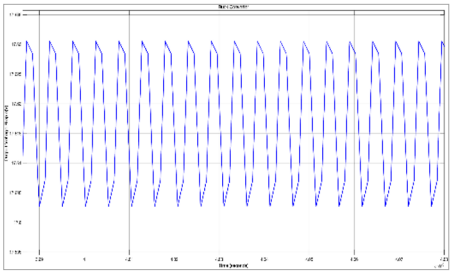

Figure 3. (d) Buck Converter -Output Voltage Ripple

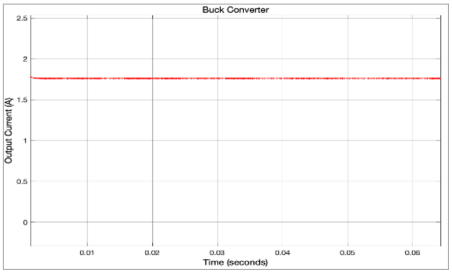

Figure 3. (e) Buck Converter - Output

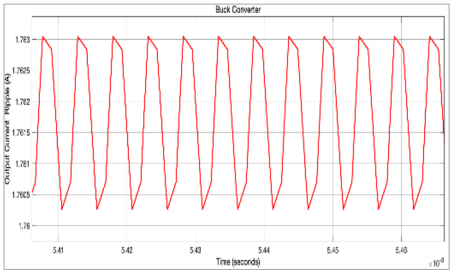

Figure 3. (f) Buck Converter -Output Current Ripple

Figure 3. Simulation Output of Buck Converter

The simulation model and the results of buck converter are shown in the fig.2 and fig.3. The output voltage and current are measured and the ripples are calculates. The fig.3.(a) shows the input voltage of 36V and fig.3(b) show the pulses to the switch for the frequency of 195 KHz. The output voltage and output voltage ripple are shown in the fig.3(c) and fig.3. (d). The output voltage is measured as 17.6V whereas the ripple is 0.029V. The output current and output current ripple are shown in the fig.3(e) and fig.3.(f). The output current is measured as 1.76 A whereas the ripple is 0.03A.

2.2 Boost Converter

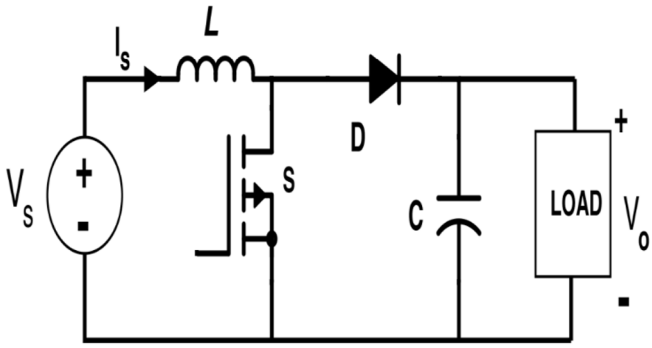

Figure 4. Boost Converter

The fig.4 shows the boost converter. When the switch is turned ON diode won't conduct makes the circuit as short circuit. When the switch is turned OFF the diode starts conducting and makes the circuit as short circuit. The voltage is stepped up in this converter. The output DC voltage is greater than the input DC voltage for the boost converter.[5]

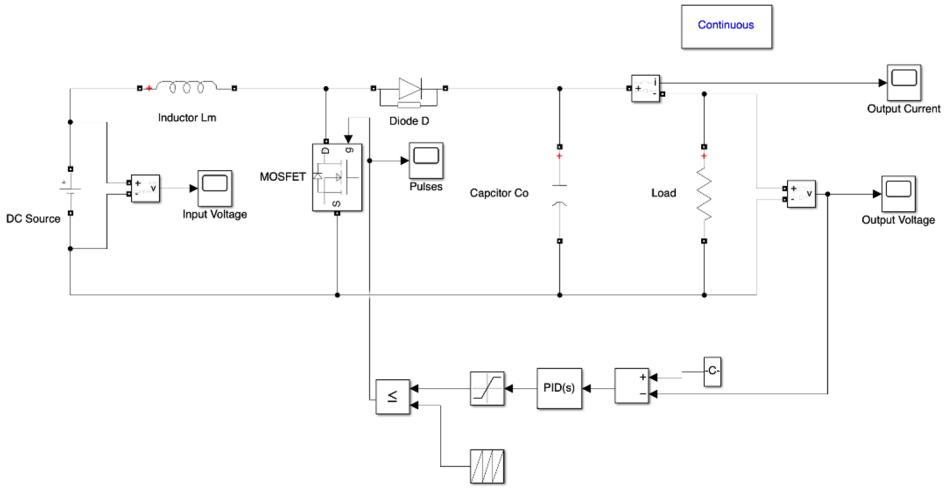

Figure 5. Simulation Model of Boost Converter

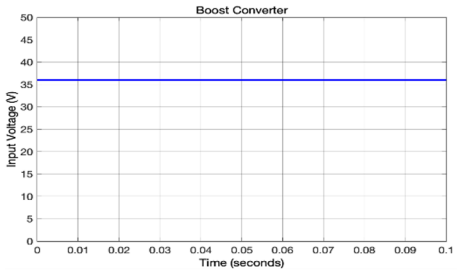

Figure 6. (a) Boost Converter - Input Voltage

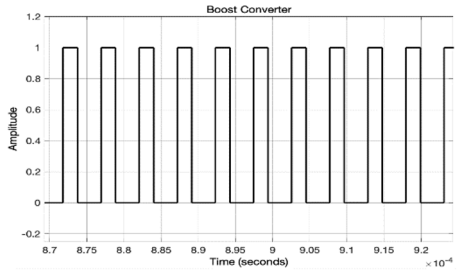

Figure 6. (b) Boost Converter - Pulses

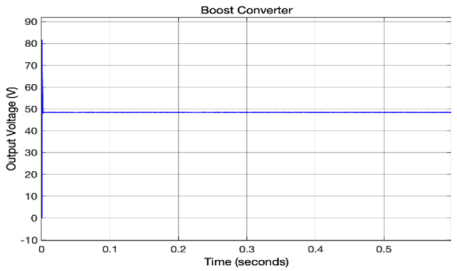

Figure 6. (c) Boost Converter - Output Voltage

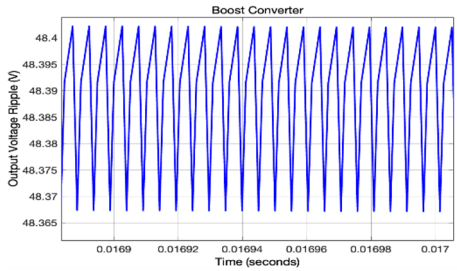

Figure 6. (d) Boost Converter - Output Voltage Ripple

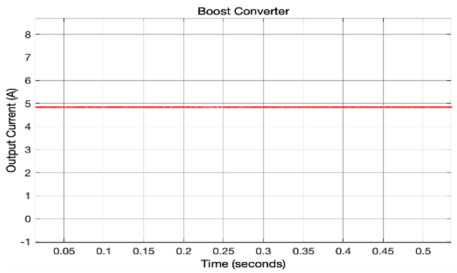

Figure 6. (e) Boost Converter - Output Current

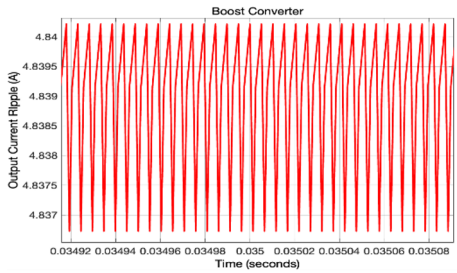

Figure 6. (f) Boost Converter - Output Current Ripple

Figure 6. Simulation Output of Boost Converter

The simulation model and the results of buck-boost converter are shown in the fig.8 and fig.9. The output voltage and current are measured and the ripples are calculated. The fig.9.(a) shows the input voltage of 36V and fig.9(b) show the pulses to the switch for the frequency of 195 KHz. The output voltage and output voltage ripple are shown in the fig.9(c) and fig.9.(d). The output voltage is measured as -33.2V whereas the ripple is 0.035V. The output current and output current ripple are shown in the fig.9(e) and fig.9.(f). The output current is measured as 3.32 A whereas the ripple is 0.04A.

2.3 Buck-Boost Converter

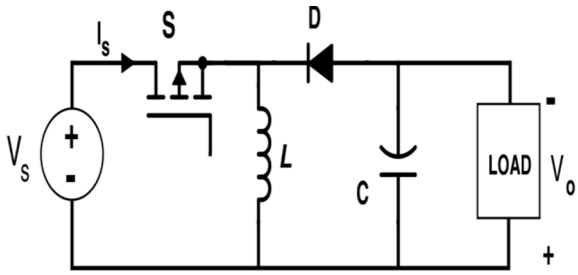

Figure 7. Buck -Boost Converter

The fig.7. show the circuit diagram of buck-boost converter. When the Switch is turned OFF it represents a short circuit ideally offering zero resistance to the flow of current the polarity of the inductor is reversed and the energy stored in the inductor is released and is ultimately dissipated in the load resistance and If duty cycle is lesser than 0.5 the output voltage is larger than the input; and if duty cycle is greater than 0.5, the output is smaller than the input. If duty cycle is equal to 0.5 the output voltage is equal to the input voltage.[5]

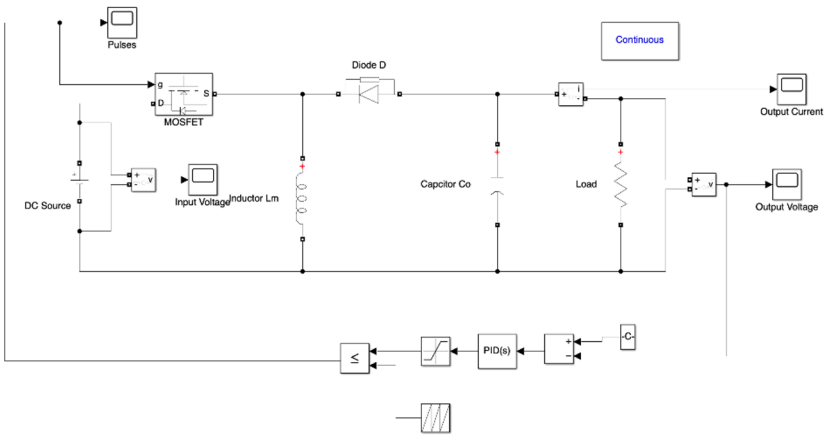

Figure 8. Simulation Model of Buck -Boost Converter

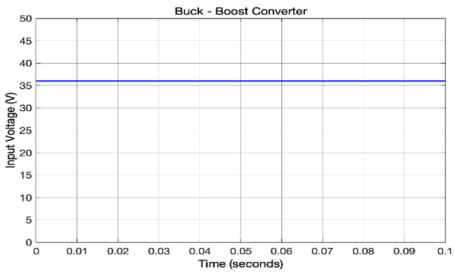

Figure 9. (a) Buck - Boost Converter - Input Voltage

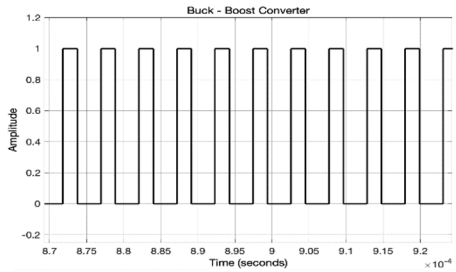

Figure 9. (b) Buck - Boost Converter - Pulses

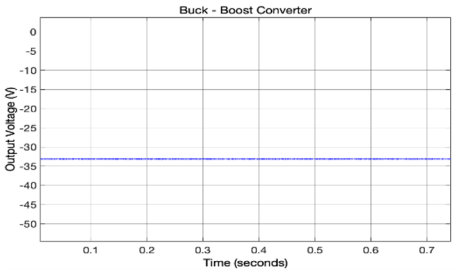

Figure 9. (c) Buck - Boost Converter - Output Voltage

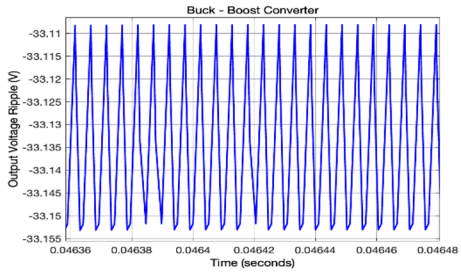

Figure 9. (d) Buck - Boost Converter - Output Voltage Ripple

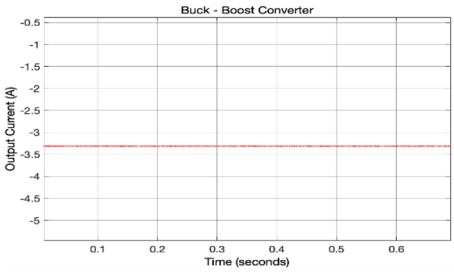

Figure 9. (e) Buck - Boost Converter - Output Current

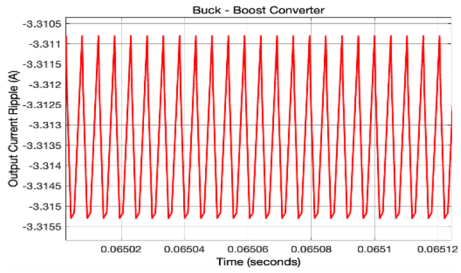

Figure 9. (f) Buck - Boost Converter - Output Current Ripple

Figure 9. Simulation Model of Buck -Boost

The simulation model and the results of buck-boost converter are shown in the fig.8 and fig.9. The output voltage and current are measured and the ripples are calculated. The fig.9.(a) shows the input voltage of 36V and fig.9(b) show the pulses to the switch for the frequency of 195 KHz. The output voltage and output voltage ripple are shown in the fig.9(c) and fig.9.(d). The output voltage is measured as -33.2V whereas the ripple is 0.035V. The output current and output current ripple are shown in the fig.9(e) and fig.9.(f). The output current is measured as 3.32 A whereas the ripple is 0.04A.

2.4 KY Converter

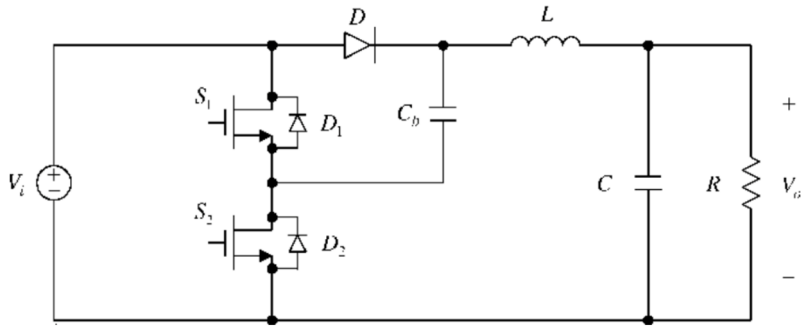

Figure 10. KY Converter

KY Boost Converter, is a non-isolated DC-DC boost converter with minimum voltage ripple. KY boost converter operates in CCM keeping the output current non-pulsating leading to reduced voltage stress across the output capacitor resulting low output voltage ripples in the order of few hundred mV. When the switch S1 is turned on and S2 is turned off, the inductor gets magnetized. magnetized and capacitor Cb is discharged. When the switch S1 is turned off and S2 is turned on, the inductor gets demagnetized and capacitor Cb is charged.[6-8]

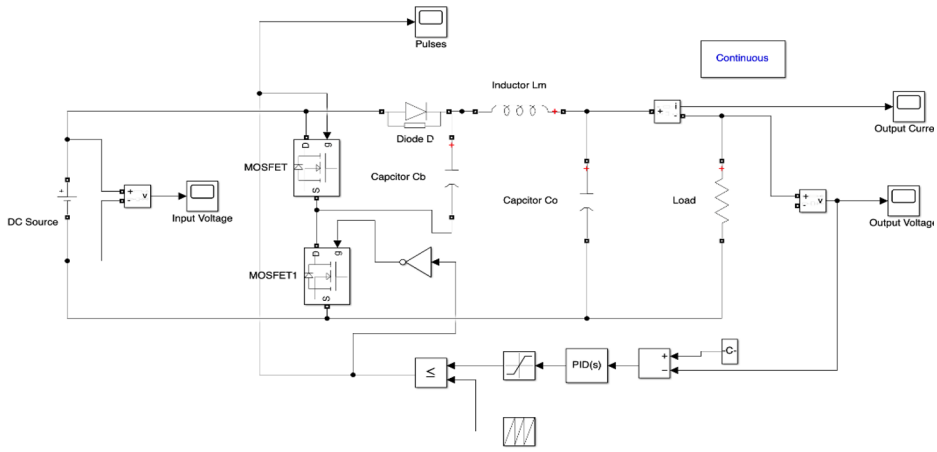

Figure 11. Simulation Model of KY Converter

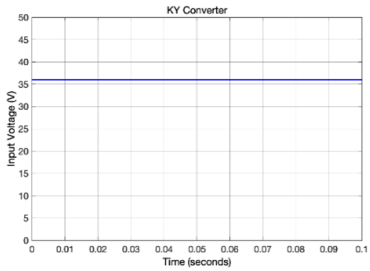

Figure 12. (a)KY Converter - Input Voltage

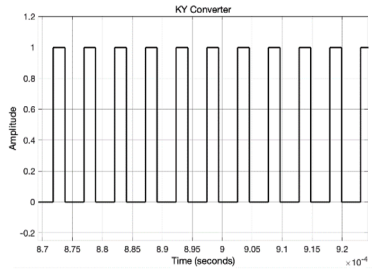

Figure 12. (b) KY Converter - Pulses

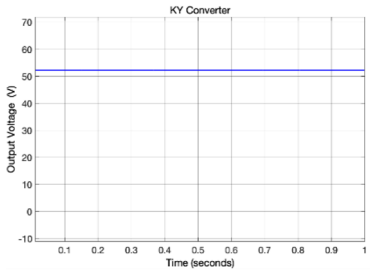

Figure 12. (c) KY Converter - Output Voltage

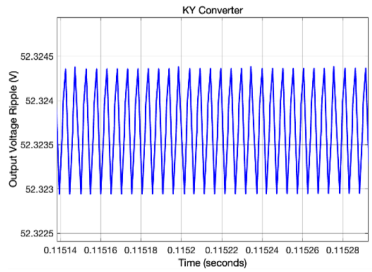

Figure 12. (d)KY Converter - Output Voltage Ripple

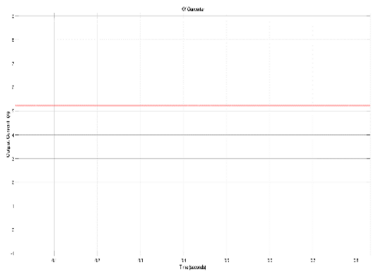

Figure 12. (e) KY Converter - Output Current

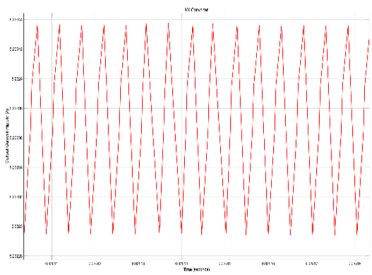

Figure 12. (f) KY Converter - Output Current Ripple

Figure 12. Simulation Output of KY

The simulation model and the results of KY converter are shown in the fig.11 and fig.12. The output voltage and current are measured and the ripples are calculated. The fig.12.(a) shows the input voltage of 36V and fig.12(b) show the pulses to the switch for the frequency of 195 KHz. The output voltage and output voltage ripple are shown in the fig.12(c) and fig.12.(d). The output voltage is measured as 52.3V whereas the ripple is 0.002V. The output current and output current ripple are shown in the fig.12(e) and fig.12.(f). The output current is measured as 5.2 A whereas the ripple is 0.0002A.

Table 1. Comparative Analysis of DC-DC Converters

Parameters	Buck Converter	Boost Converter	Buck-Boost Converter	KY Converter
Input voltage (V)	36	36	36	36
Output voltage (V)	17.62	48.4	-33.2	52.3
Output Current (A)	1.76	4.84	3.32	5.2
Resistor (Ω)	10	10	10	10
Inductor (µH)	7.74	7.74	7.74	7.74
Capacitor Cb (µf)	-	-	-	375.6
Capacitor Co (µf)	194.87	194.87	194.87	194.87
Duty Cycle	38	38	38	38
Switching Frequency (kHz)	195	195	195	195
Voltage Ripple	0.029	0.084	0.035	0.002
Current Ripple	0.03	0.08	0.04	0.0002

The table1 show the comparative analysis of various DC-DC converters. On analysing various converters like buck, boost, buck-boost under same design parameters we found that KY converter showed very low ripples and non-pulsating current. Also, among the other converters the efficiency seemed comparatively high and thus we chose KY converter. Closed loop control systems are more accurate even in the presence of non-linearities. The sensitivity of the system may be made small to make the system more stable. On analysing the closed loop control of various converters like buck, boost, buck-boost and KY under same design parameters we found that KY converter the system seemed very stable.

3. Proposed system

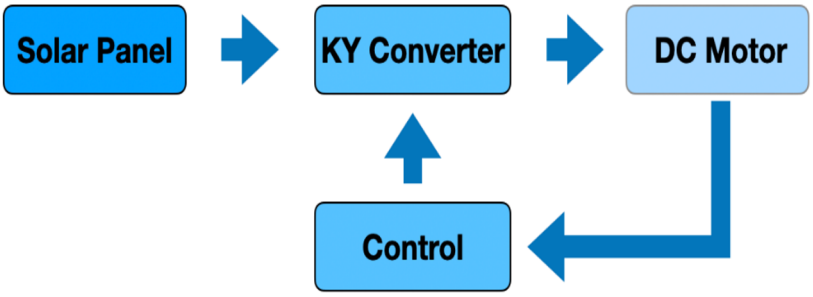

Figure 13. Block diagram of Proposed System

The fig.13 shows the block diagram of the proposed system. A voltage increase converter is proposed which makes use of a rate pump and a coupled inductor in the KY converter. As a greenhouse-boost converter blended with synchronous rectification that is in the form of replacing diodes with MOSFET switches, Its far voltage-set up converter is operated. A PV cell that is a solar cell fed to the proposed converter. DC output is produced.To enhance the DC voltage the increased form of converter combines the KY converter. Right here the running of KY converter, sun cell is given to the KY converter sun-PV cells produce energy at once with the aid of converting the sun energy into electricity that is acquired from sun cell is given to the KY converter which is the combination of boost converter is used to setup the dc voltage. The dc voltage is fed to the DC motor. Thus, it can be used for low power applications. For supplying the load properly, the power obtained often needs better DC-DC conversion.

Table 2. Design parameters of proposed system

Parameters	Value	Parameters	Value
Input voltage (V)	$V_{in} = 36V$	Inductor Ripple Current	dI = 40 % of I_L =5.552A
Output voltage (V)	$V_o = 50V$	Voltage Across Inductor	$2V_{in} - V_o = 22V$
Output Current (A)	$2V_{in} - V_o = 22V$	Inductor (μH)	$V_L * \frac{dt}{dI}$ =7.72μH
Input Power	$P_{in} = P_{out}$=250W	Capacitor Cb (μF)	375.6
Input Current	$I_{in} = P_{in} = P_{out}$=250W	Capacirtor Co (μF)	194.87
Duty Cycle	D= 38=0.38	Switching Frequency(kHz)	195
Voltage Gain	1+D =1.38	Voltage Ripple	0.001
Inductor Current	$I_L = 2I_{in} = 13.88A$	Current Ripple	0.0003

Table 2 shows the design parameters of the proposed system. The boost converters currently used for helicopter control in wind and solar systems offer response characteristics that can be improved by implementing a KY converter instead of a boost converter. In this topology, the implementation of the KY converter is done in MATLAB/SIMULINK with respect to open loop and PID controllers. Increase the input voltage of the PV panel to an appropriate level.

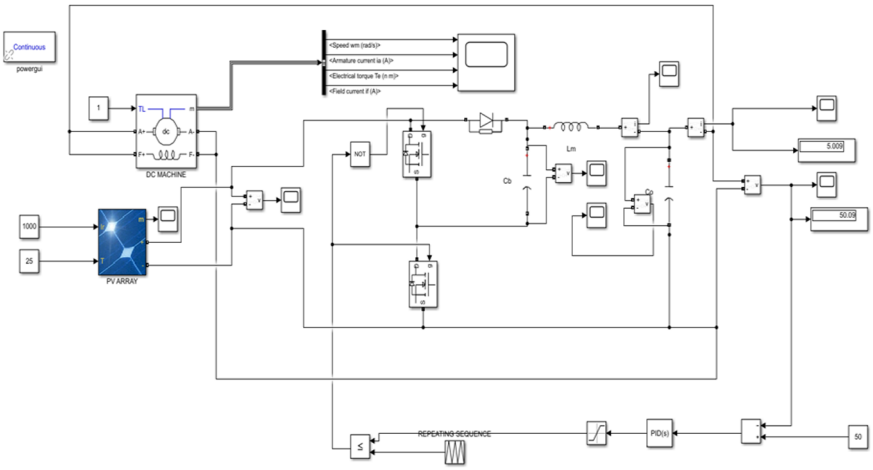

Figure 14. Simulation Model of Proposed System

The fig.14 shows the simulation model of the proposed system. The 36 volts is the input voltage given to the KY converter and gives the output voltage and output current of 50 volts, 5 A as per the design calculations and compared to the other converters, the voltage ripple and the current ripple is very small. The voltage ripple is 0.004 and the current ripple is 0.0002. The output of the KY converter circuit is sent directly to the load. Continuous output with reduced ripple count and better transient response can be achieved. The output of the KY converter circuit is given directly to the load. A continuous output with reduced ripple counts and a better transient response can be obtained. We have implemented the closed loop of KY converter using PID control in our project which has been fed to the DC motor. Hence for implementation in low power applications a ripple free output with comparatively high efficiency can be obtained.

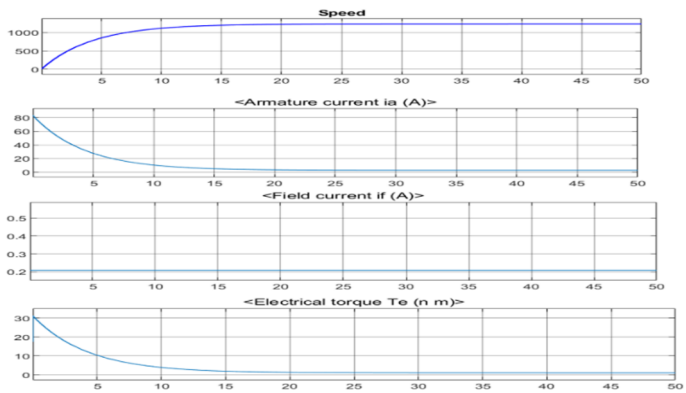

Figure 15. Simulation Output characteristics of DC motor

4. Conclusion

For extensive variable-speed drives, direct current motors with variable characteristics are used. A high starting torque is provided by a DC motor and it is also possible to obtain speed control over a wide range. Conventionally DC motors are suitable for various applications as their characteristics are highly efficient but in our paper, to be used for low power applications it is used in combination with KY converter. In modern society, portable electronic devices such as: mobile phones, laptops and digital still cameras widely used DC-DC converters. In order to convert the battery voltage into different voltage domains. In most instances, For power supply applications using low Voltage battery, it is necessary to uplift from low voltage to high voltage, thus a boost converter is usually applied, but with a pulsating output current leading to a large voltage ripple. The converter has many advantages such as no ripple current, low output ripple and good load transient response, which can eliminate the problems of the boost converter, so the KY converter can be used at instead of the boost converter, which has more advantages over good output response for conventional boost converters when operating in continuous conduction mode. The solar panel is used to supply direct current, and this direct voltage is stored in the battery. To increase the voltage level, the voltage thus stored in the battery is then supplied to the converter KY. The output of the converter circuit KY is then directly supplied to the load. Thus, a continuous output with a reduced number of ripples can be obtained, and a better transient response can be obtained.

References

1. J. S. A. Rahavi, T. Kanagapriya and R. Seyezhai, Design and analysis of Interleaved Boost Converter for renewable energy source, International Conference on Computing, Electronics and Electrical Technologies(ICCEET), (2012).
2. Kshitij Tiwari, Tirumalachetty , Harinarayana, Increasing the Efficiency of Grid Tied Micro Wind Turbines in Low Wind Speed Regimes, published by Smart Grid and Renewable Energy.
3. V. S. Patil, S. Angadi and A. B. Raju, "Four quadrant close loop speed control of DC motor," 2016 International Conference on Circuits, Controls, Communications and Computing (I4C), Bangalore, India, pp. 1-6,(2016), doi: 10.1109/CIMCA.2016.8053305.
4. Safwan A. Hamoodi, ,Rasha A. Mohammed ,Bashar M. Salih , DC Motor Speed Control Using PID Controller Implementation by Simulink. International Journal of Electrical Engineering. ISSN 0974-2158 Volume **11**, Number 1, (2018), pp. 39-49. 72
5. Vivek Sharma, Chiranjeev Panwar, Comparative analysis of PV FED DC-DC converters. International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE), (2014)
6. P. Hazra, R. K. Saha, S. Debnath, D. Saha and P. Dutta, "Designing A DC – DC High Power Boost Converter," 4th International Conference on Energy, Power and Environment (ICEPE), Shillong, India, 2022, pp. 1-6, (2022), doi: 10.1109/ICEPE55035.2022.9797930.
7. Rexy, N. Mary, J. Starlin and R. Elizabeth, "Interleaved Boost Converter with Fuzzy Logic Controller," First International Conference on Electrical, Electronics, Information

and Communication Technologies (ICEEICT), Trichy, India, 2022, pp. 1-7, (2022) doi: 10.1109/ICEEICT53079.2022.976849

8. Meera R Nair, Ms. Priya Jose, Voltage Gain Enhancement Using Ky Converter ,IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320- 3331, PP 27-3.
9. M. Pushpavalli, P. Abirami and K. Vasanth , Performance of Negative KY Boost Converter Indian Journal of Science and Technology, Vol **7(8),** 1049–1059, August (2014).
10. X. Du et al., "A digital PWM controlled KY step-up converter based on passive sigma-delta modulator," IEEE 3rd International Future Energy Electronics Conference and ECCE Asia (IFEEC 2017 - ECCE Asia), Kaohsiung, Taiwan, pp. 260-264,(2017) doi: 10.1109/IFEEC.2017.7992047.
11. SK. Saidalli, B. Seshagiri, V.S.N. Narasimha Raju, A Novel Soft-Switching Based Closed Loop KY Converter with RippleFree Current, International Journal of Engineering Trends and Technology (IJETT) – Volume **56** Number 1- February, (2018).
12. S. R. Bhagwatkar, A. P. Dhande, Closed Loop Speed Control of DC Motor, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395- 0056 Volume: **05** Issue: 03 | Mar-(2018).
13. Harshitha K T and K.V.Shettigar , Closed Loop Speed Control Analysis of DC Motor , International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering Nitte Conference on Advances in Electrical Engineering NCAEE-2016 NMAM Institute of Technology, Nitte Vol. **4**, Special Issue 2, April (2016).
14. Design of single closed loop control for chopper fed DC motor drive using IMC principles. Boulbaba Guedri is with the Electrical Engineering Department, The National Higher Engineering School of Tunis (ENSIT), Bab Manara, Tunis, Tunisia. 2015 16th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA).
15. Xumei Lin, Yunfei China.Yulu , Design and Research of DC Motor Speed Control System ,Published in Chinese Automation Congress (CAC) (2018).
16. M. A. Fkirin, , Speed Control of DC Motor Using PID Controller Based on Artificial Intelligence Techniques, ,Proceedings of 1st IEEE International Conference on Control, Decision and Information Technologies (CoDIT 2013), Tunisia (Hammamet), (2013)
17. Akhil Raj P, Sabha Raj Arya, Solar Fed DC-DC Converter for Small Power Applications, IEEE 1st International Conference on Energy, Systems and Information Processing (ICESIP), (2019)