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RESEARCH ARTICLE

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STUDY ON DYNAMIC BEHAVIOUR OF PMBLDCM USING DIFFERENT DC-DC CONVERTERS

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ABSTRACT

This paper deals with the study on dynamic performance of PMBLDCM by varying input voltage. Here different dc-dc converters are used for comparision like buck-boost, sepic, cuk and bridgeless cuk converters.

These converters are connected between single phase diode bridge rectifier and a three phase inverter. The three phase inverter is used as electronic commutator to operate PMBLDCM.

But in the case of bridgeless cuk converter, the DBR and the converter is replaced by bridgeless cuk converter. This maintains the power factor to nearly unity and also improves the efficiency of the overall system due to the reduction in number of semiconductor switches.

This entire set is operated and simulated in MATLAB simulink environment and different power quality parameters like power factor, total harmonic distortion, crest factor, distortion power factor are compared for different converters mentioned above.

Keywords—Buck-boost converter, Cuk converter, Bridgeless Cuk converter and Sepic converter.

INTRODUCTION

Now- a-days PMBLDC motors are used in low power applications due to its features like high efficiency, wide speed range, less maintenance etc. It is also called as synchronous motor due to the use of permanent magnets on the rotor. The solid state switches in 3-phase voltage source inverter helps in commutating in PMBLDCM. Due to these advantages the PMBLDCM has many applications like air conditioning systems and electric traction.

The PMBLDCM is fed from single phase ac supply via diode bridge rectifier followed by dc link capacitor. The current drawn from the ac mains is pulsed current having peak higher than the amplitude of the fundamental input current at ac mains due to uneven charging of dc link capacitor. Due to this power factor goes lesser and higher total harmonic distortion at ac mains and higher crest factor.

In this paper, different converters are used for the PFC, amongst which cuk and bridgeless cuk topologies emphasize on low harmonic contents and near unity power factor drawn from ac mains.

In most of the PMBLDC drives, the overall efficiency of the drive system is very low. The reason is that the dc link capacitor draws pulsed current which results in harmonics due to uncontrolled charging. Hence the power factor correction converter is implemented. Most of these usually use boost topology at the front end, due to which switching losses is high due to the presence of diode

bridge. Hence there is a need to maximize the overall efficiency of the drive system.

Bridgeless topologies are one of the best suited which can minimize the switching losses by reducing the number of power semiconductor switches in the current conducting path. Bridgeless topologies avoids the usage of diode bridge rectifier and hence the conduction losses are reduced which yields a better efficient system.

The commonly used topologies are bridgeless boost and buck bridgeless converters. But the bridgeless boost converter topology has high start up inrush current. The buck bridgeless converter has disadvantages such as low output voltage, high output voltage ripple. The sepic converter topology has high output ripple due to the discontinuous output current hence using these converter topologies reduces the overall efficiency of the drive system.

The cuk converter topology has the advantages against above mentioned topologies like easy implementation of transformer isolation, natural protection against heavy inrush current occurring at startup or overload current, lower input current rippleless electromagnetic interference associated with the discontinuous conduction mode (DCM) topology.

The usage of DCM again add up advantages like near unity power factor, the power switches are turned on at zero current and the output diodes are turned off at zero current.

Design of converter for MATLAB simulation:

BUCK-BOOST CONVERTER:

fig: 1 shows the schematic of the proposed Buck-Boost PFC converter based PMBLDCM drive. This controller is operated to maintain constant dc-link voltage (V_{dc}) with PFC done at ac mains.

In this paper, the source voltage is varied from 300V to 120V keeping speed of the motor constant at 1500rpm. The design of the simulation circuit is done by assuming the following parameters:

$$d = \frac{Vo}{Vo + Vin} = 0.5$$

$$L > \frac{(1-D)^2 R}{2f} = 168.36\mu H$$

$$C > \frac{D}{Rf(\frac{\Delta Vo}{Vo})} = 10.96\mu F$$

$$R = 60\Omega$$

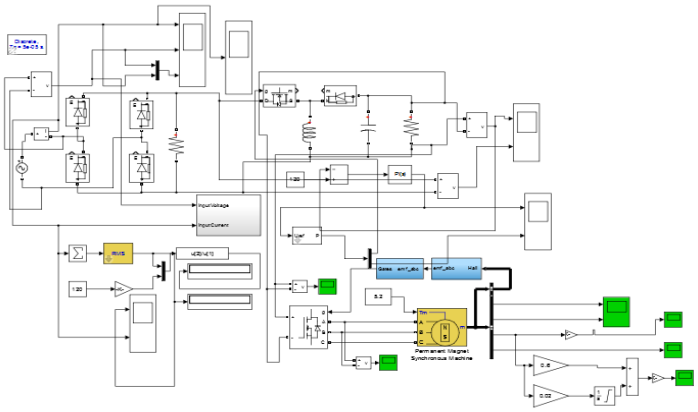


Fig 1: Output power: 2HP, input frequency: 40KHz

SEPIC CONVERTER:

fig:2 shows the schematic of the proposed Sepic PFC converter based PMBLDCM drive. The design equations for this converter are as follows:

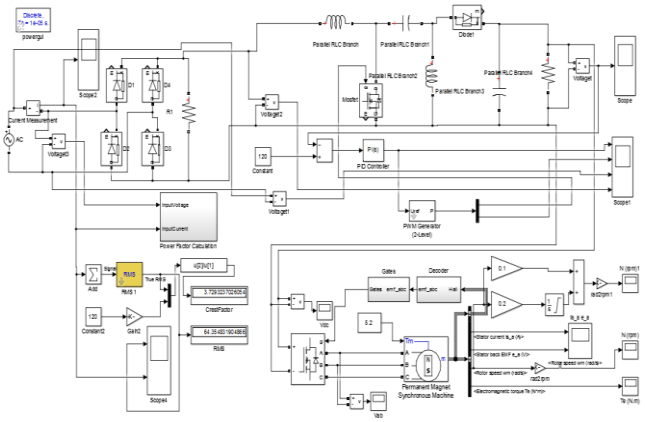


Fig:2 Theschematic of the proposed Sepic PFC converter based PMBLDCM drive.

$$L_1 = \frac{Vsd}{f\Delta i_{L1}} = 100\mu H$$

$$L_2 = \frac{V_s d}{f\Delta i_{L2}} = 100\mu H$$

$$C_1 = \frac{Vod}{R\Delta V_{c1} f} = 1\mu F$$

$$C_2 = \frac{Vod}{Rf\Delta V_{c2}} = 5mF$$

$$R = 60\Omega$$

CUK CONVERTER:

Fig:3 shows the proposed schematic circuit diagram for cuk converter. The design equations for this converter are as follows:

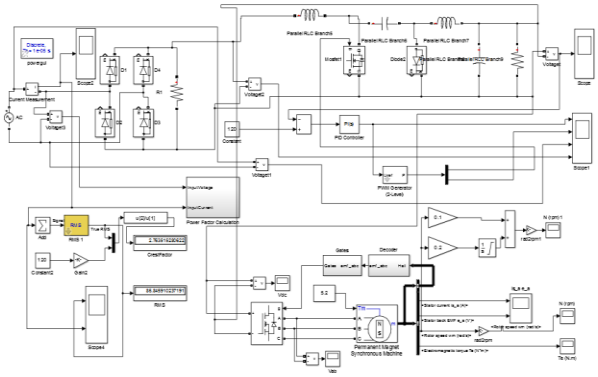


Fig:3 The proposed schematic circuit diagram for cuk converter.

$$L_1 = \frac{V_s d}{f\Delta i_{L1}} = 7mH$$

$$L_2 = \frac{V_s d}{f\Delta i_{L2}} = 7mH$$

$$C_1 = \frac{V_o d}{Rf\Delta V_{C1}} = 5\mu F$$

$$C_2 = \frac{(1-d)V_o}{8C_2L_2f^2\Delta V_o} = 50mF$$

$$R = 60\Omega$$

BRIDGELESS CUK CONVERTER:

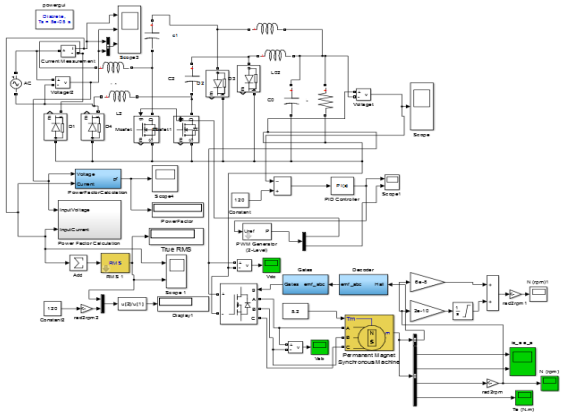


Fig 4: The circuit diagram of converter

The bridgeless cuk converter proposed here yields best result and nearly unity power factor and the system has high efficiency. The circuit diagram of converter is as shown in fig 4.

$$L_1 = L_2 = 1143 * 10^{-7}H$$

$$L_{01} = L_{02} = 7mH$$

$$C_1 = C_2 = 1000\mu F$$

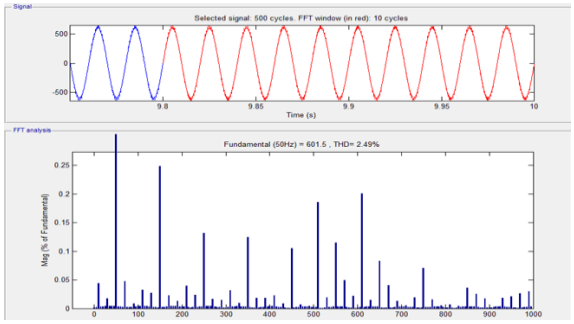
$$C_0 = 500mF$$

SIMULATION RESULTS:

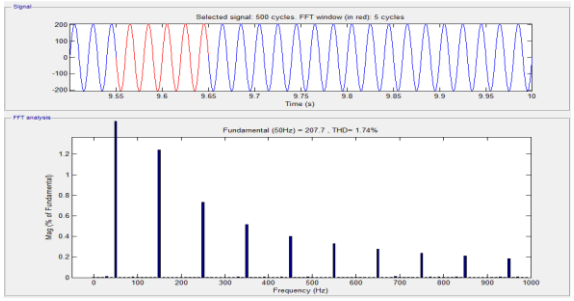
The simulation circuit is simulated in MATLAB and the pf is calculated by using the internal circuit available in matlab software and pf for different converters Buck-Boost, Sepic, Cuk and Bridgeless cuk converters are calculated. Also the waveforms of input voltage a nd current is also obtained. Next the THD is calculated by using FFT analysis circuit available internally in matlab software and the THD of input current is calculated. The crest factor is calculated using the relation peak by rms value. The distortion factor is calculated using the formula.

$$DISTORTION\ POWER\ FACTOR = \frac{1}{\sqrt{1+THD^2}}$$

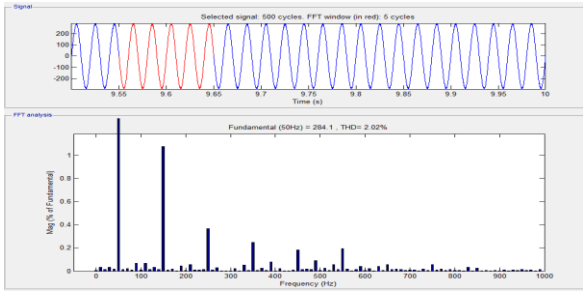
Simulation waveforms for the calculation of THD for BUCK-BOOST converter:



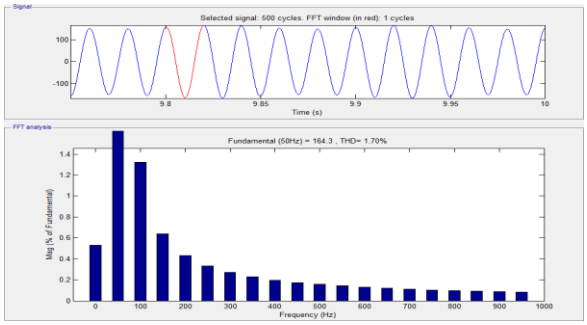
Simulation waveforms for the calculation of THD for SEPIC converter:



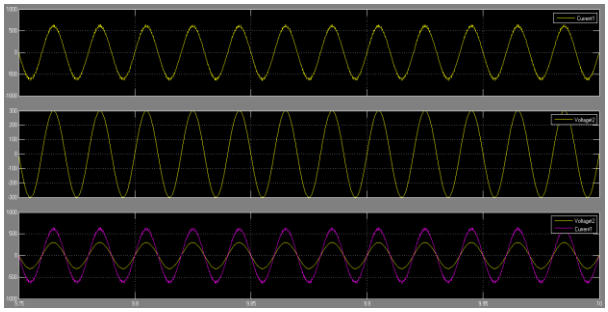
Simulation waveforms for the calculation of THD for CUK converter:



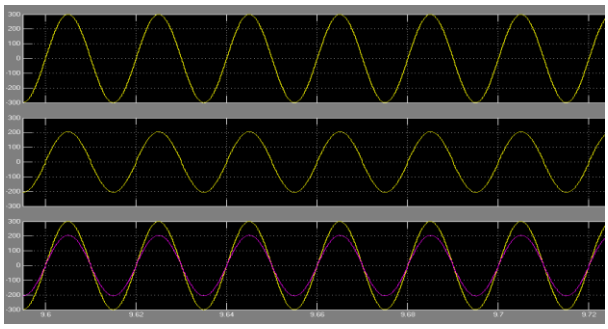
Simulation waveforms for the calculation of THD for BRIDGELESS CUK converter:



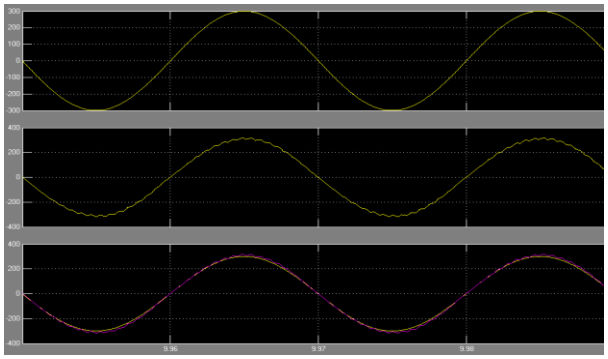
Simulation waveforms of input side voltage and current for PF calculation for BUCK-BOOST converter:



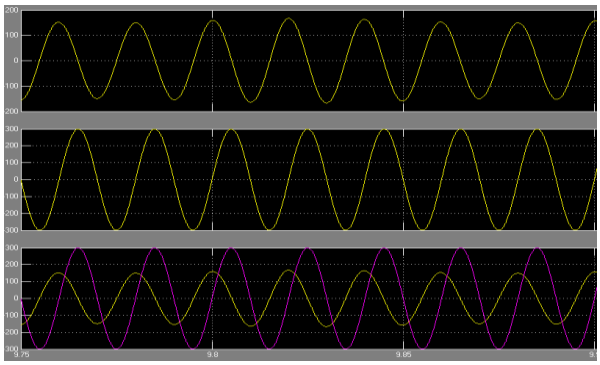
Simulation waveforms of input side voltage and current for PF calculation for SEPIC converter:



Simulation waveforms of input side voltage and current for PF calculation for CUK converter:



Simulation waveforms of input side voltage and current for PF calculation for BRIDGELESS CUK converter:



COMPARISION OF PF, THD, CF, DPF:

BUCK-BOOST CONVERTER:

PEAK SOURCE VOLTAGE(V_s) volts	POWER FACTOR	TOTAL HARMONIC DISTORTION(%)	CREST FACTOR	DISTORTION POWER FACTOR
300V	1	2.49	1.3540	0.3726
270V	1	2.66	1.3523	0.3518
240V	1	2.86	1.3520	0.3300
210V	1	3.12	1.3508	0.3052
180V	1	3.44	1.3478	0.2791
150V	1	3.84	1.3442	0.2520
120V	1	4.42	1.3395	0.2206

SEPIC CONVERTER:

PEAK SOURCE VOLTAGE(V_s) volts	POWER FACTOR	TOTAL HARMONIC DISTORTION(%)	CREST FACTOR	DISTORTION POWER FACTOR
300V	1	1.74	3.9198	0.4982
270V	1	1.94	3.9057	0.4581
240V	1	2.15	3.8882	0.4217
210V	1	2.42	3.8656	0.3819
180V	1	2.77	3.8368	0.3395
150V	1	3.28	3.7923	0.2916
120V	1	4.01	3.7293	0.2419

CUK CONVERTER:

PEAK SOURCE VOLTAGE(V_s) volts	POWER FACTOR	TOTAL HARMONIC DISTORTION(%)	CREST FACTOR	DISTORTION POWER FACTOR
300V	0.9999	2.02	2.8540	0.4436
270V	0.9999	2.08	2.8485	0.4332
240V	0.9999	2.12	2.8420	0.4266
210V	0.9999	2.15	2.8299	0.4217
180V	0.9999	2.20	2.8140	0.4138
150V	0.9999	2.24	2.7924	0.4076
120V	0.9999	2.30	2.7635	0.3987

BRIDGELESS CUK CONVERTER:

PEAK SOURCE VOLTAGE(V_s) volts	POWER FACTOR	TOTAL HARMONIC DISTORTION(%)	CREST FACTOR	DISTORTION POWER FACTOR
300V	0.9997	1.70	1.464	0.5070
270V	0.9997	1.25	1.369	0.6246
240V	0.9997	1.94	1.459	0.4581
210V	0.9997	0.76	1.383	0.7961
180V	0.9997	0.57	1.392	0.8687
150V	0.9997	0.42	1.385	0.9219
120V	0.9997	0.28	1.391	0.9629

CONCLUSION

The study of the behaviour of the PMBLDCM with different converters like Buck-Boost, Sepic, Cuk and Bridgeless Cuk converters are studied by varying the source voltage. The calculation of PF, THD, CF and DPF is done and tabulated for different converters mentioned above. Amongst these converters, Cuk and bridgeless converters have got better results and less harmonic distortions. The waveforms for input side voltage and current, also for THD is obtained for the above mentioned converters.

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