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BLDC Motor Speed Control by ZETA Converter

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ABSTRACT:-This study deals with varying the speed of BLDC motor by using zeta convertor. The three phase input to BLDC motor is given by three phase inverter working in 120⁰ mode of conduction. The zeta convertor is used to vary the input DC voltage to three phase inverter hence output voltage of three phase inverter also varies which varies the speed of BLDC motor. The output voltage of zeta is varied by varying the duty cycle of zeta by using dspic30f. Design of zeta convertor is done such that it operates in discontinuous inductor current mode.

I. INTRODUCTION

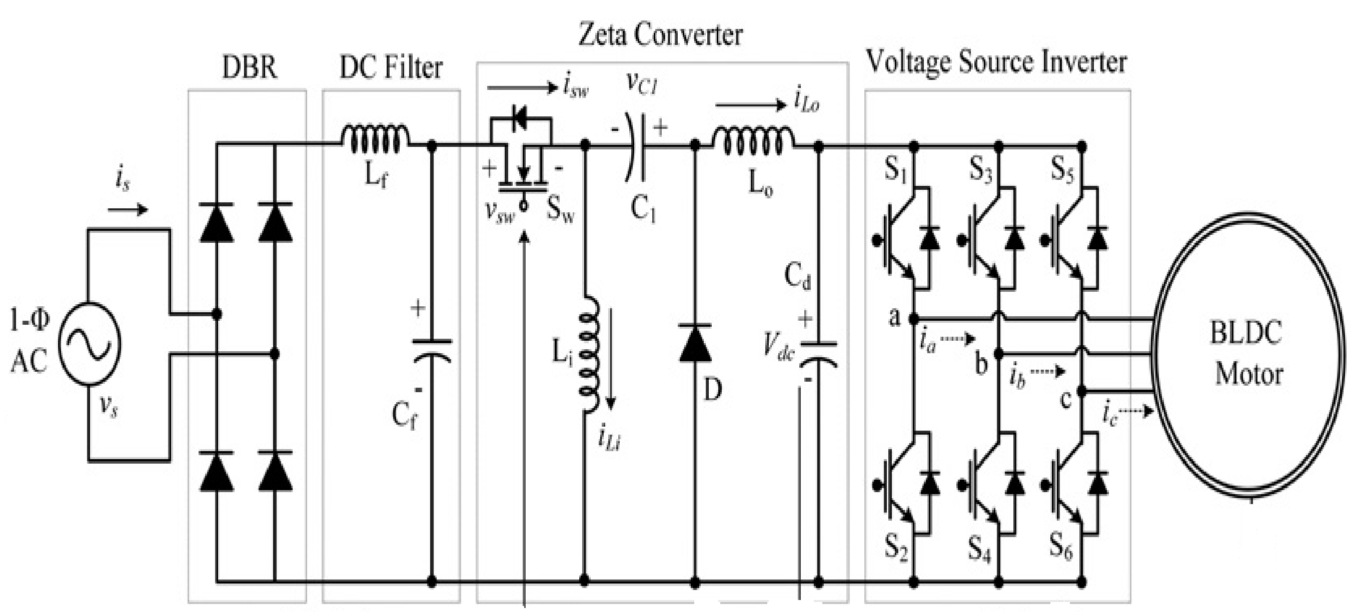
Brushless dc motor are synchronous motors which are given supply with an inverter which converts the available dc into ac which is given to winding of motor with the help of a closed loop controller. Brushless dc electric motor is also known as electronically commutated motor.

The BLDC motor consists of permanent magnets on rotor and winding placed on stator. Permanent magnets of rotor produce rotor flux and the windings of stator produce magnetic poles. The rotor gets attracted by stator poles. By utilizing a proper sequence for supplying the stator winding, rotating field on the stator can be produced and maintained. The rotor chases after the electromagnet poles on the stator and thus starts rotating at synchronous speed decided by frequency of supply from staor.

Conventional DC motor have properties like higher ŋ and linear ҭ vs N characteristics there speed control is easy and does complex hardware are not required. There drawback are that they periodic maintenances are needed, the brushes of the commentator produce sparks. BLDC motor has long operating life, high dynamic response.

There are two ways to control the speed of BLDC motor, in conventional way we feed the bldc motor by boost convertor, the dc link voltage (output of boost convertor or input of VSI) is maintained constant with the help of boost convertor. Switches of VSI are controlled by PWM for speed contol. Now this type of configuration have drawback of high switching losses as we are using switching of VSI switches for speed control which varies according to PWM switching frequency. The other and better way is supplying a variable dc voltage to VSI at input for speed control of bldc motor, this allows VSI to operate in fundamental switching frequency for achieving speed control of bldc motor. The variable dc-link voltage is achieved by using a zeta convertor which is operated in discontinuous inductor current mode operation.

II. CIRCUIT DIAGRAM OF PROPOSED SYSTEM



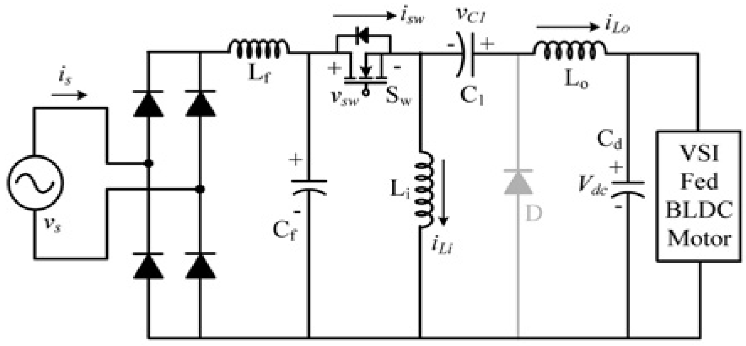
III. ZETA CONVERTOR OPERATION

The zeta convertor is operated in DICM(discontinuous inductor current mode), it means current in the inductor in input side is discontinuous, whereas current remains in continuous conduction for a complete switching cycle in the inductor in output side and voltage across the Ci remain in continuous conduction for a complete switching cycle. The operation of zeta convertor can be divided into three periods which are;

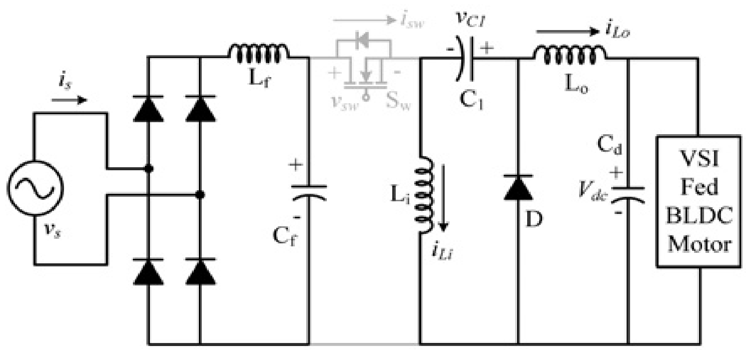
Period first ($0 < t < t_1$): In this period we turn on the switch due to which the charging of zeta's Li and the Lo starts. The Ci discharges in this period and charge the Cd. Now, due to this voltage across Ci decreases and voltage across the Cd increases.

Period second ($t_1<t<t_2$): When the switch is turned off, the stored energy of the Li and Lo is discharged to charge Ci and Cd. The diode starts conducting in this period. Now due to charging the voltage across the Ci and Cd voltage increases in this period.

Period third ($t_2<t<t3$): This is discontinuous conduction period that is in Li the current reaches zero and becomes negative. The required power to VSI feeding brushless dc motor is provided by Cd therefore the dc link voltage starts decreasing in this period.



a



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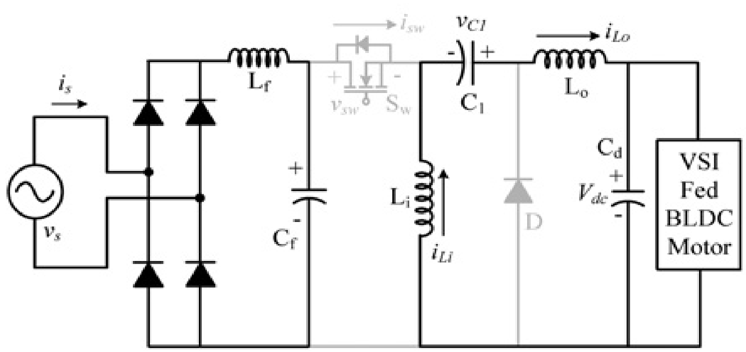

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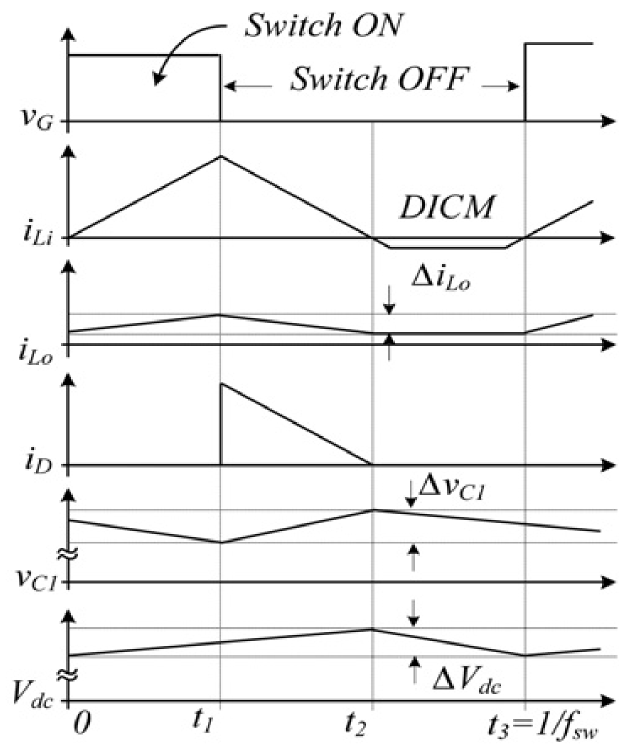


d

IV. DESIGN OF ZETA CONVERTER

A.) Duty Cycle:-

$$D = \frac{V_{OUT}}{V_{IN} + V_{OUT}}.$$

$$= \frac{24}{24+21.60} = 0.52$$

B.) Rectifier O/P Voltage:-

$$Vinmax = Vop(rectifier) = \frac{2Em}{\pi}$$

$$= \frac{2\times24\times\sqrt{2}}{\pi}$$

$$= 21.60V$$

C.) Inductance of Coil:-

$$= \frac{VIN \times D}{2\times\Delta I\times FSW}$$

$$= \frac{21.60\times24}{2\times0.3\times0.6\times20\times10^3\times(21.60+24)}$$

$$= 1.57mH$$

D.) Flying Capacitance Cc:-

$$= \frac{D\times I}{\Delta VC\times FSW}$$

$$= \frac{24\times0.6}{(21.60+24)\times0.001\times20\times10^3\times24}$$

$$= 657.89uF$$

E.) Output Capacitance C_{out}:-

$$= \frac{\Delta I}{8\times\Delta V\times FSW}$$

$$= \frac{0.18}{8\times.00005\times20\times10^3\times24}$$

$$= 937.5\ uF$$

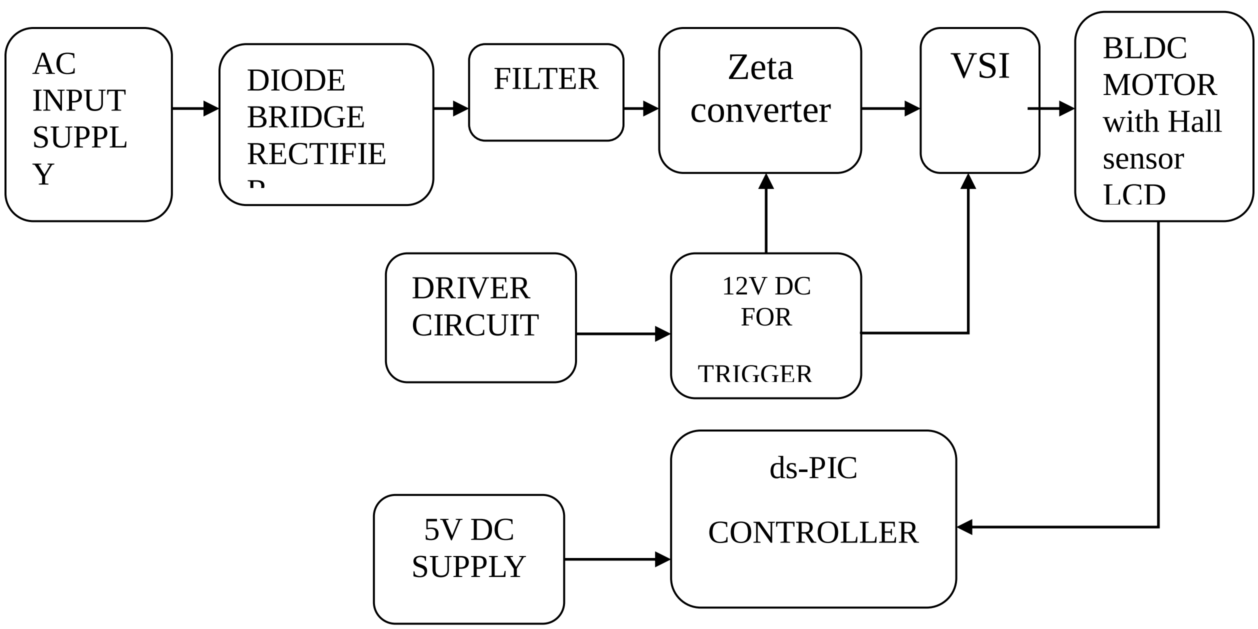
F.):-Input Capacitance C_{in}

$$= \frac{D\times I}{\Delta V\times FSW}$$

$$= \frac{0.52\times0.6}{.001\times21.60\times20\times10^3}$$

$$= 722.22\ uF$$

IV. BLOCK DIAGRAM OF PROPOSED SYSTEM



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The ac input supply is converted to dc by diode bridge rectifier. The filter is provided to reduce disturbance and unwanted ripples I dcc output of rectifier. Now the output of diode bridge rectifier is constant dc, this is converted into variable dc by zeta converter. The duty cycle of zeta converter is varied to achieve the variable voltage. The duty cycle of zeta is controlled by ds-pic. It varies it according to the required speed. The output of zeta is provided as input to three phase VSI. The output of VSI drives the bldc motor. The six switches of VSI are triggered by ds-pic through driver circuit. The driver circuit is used to convert 5v volt dc trigger generated by ds-pic to 12 volt dc trigger to be given to MOSFET switches. The LCD display is used to display the required and the actual speed of BLDC motor.

V. OBSERVATION

S.No	Vloutof Inverter (Volts)	Voutzeta (Volts)	Set Speed (Nca) (Rpm)	Actual Speed (Nac)	Duty Cycle
1.	9.7	22.3	3000	2984	.507
2.	9.1	24.5	2750	2716	.531
3.	8.3	25.6	2500	2520	.542
4.	7.5	27.1	2250	2281	.556
5.	6.7	28.3	2000	2002	.567
6.	6.0	29.1	1750	1770	.573
7.	5.1	30.1	1500	1515	.582
8.	4.4	30.8	1250	1215	.588
9.	3.7	31.7	1000	1005	.595
10.	3.1	32.5	750	791	.600
11.	2.4	33.1	556	580	.605

VI. CONCLUSION

The speed control of BLDC motor is achieved by varying the dc link voltage of VSI by using zeta convertor. The zeta convertor is designed operate in discontinuous inductor current mode . Due to low frequency switching pulses used for electronically commutating the bldc motor there are reduced losses due to switching in the VSI.

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