

Closed Loop Topology of Converter for Variable Speed PMSM Drive

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Abstract- The discontinuous mode operation (DCM) of all single-switch topologies is most suitable for low power applications, somewhere these converters there outstanding characteristics of power factor correction using a very simple control scheme with only one voltage feedback loop. The Permanent Magnet Synchronous Motor is used to construct low power rating application such as Refrigerator, Washing Machine, House-hold appliances, Medical Equipment, Wide speed range of servo drives and industrial robots. CCM fly back converter sustains the same voltage stress as, but less current stress than its DCM counterpart, when delivering the same output power. As for output voltage performance, both CCM and DCM fly back converters perform equally well in terms of output voltage regulation. In the light of efficiency, the CCM fly back converter is superior to its DCM complement, which suffers from the larger conduction and switching losses.

Index Terms - Power Quality, Total Harmonic Distortion. Topology of Fly back AC-DC Converter, High Frequency Isolation, Permanent Magnet Synchronous Motor.

I. CLOSED LOOP OF PMSM DRIVE SYSTEM

The motor drive consists of four major components, the motor, inverter, control unit and the position sensor. The components are connected in closed loop operation as shown in figure 1.1. [1]

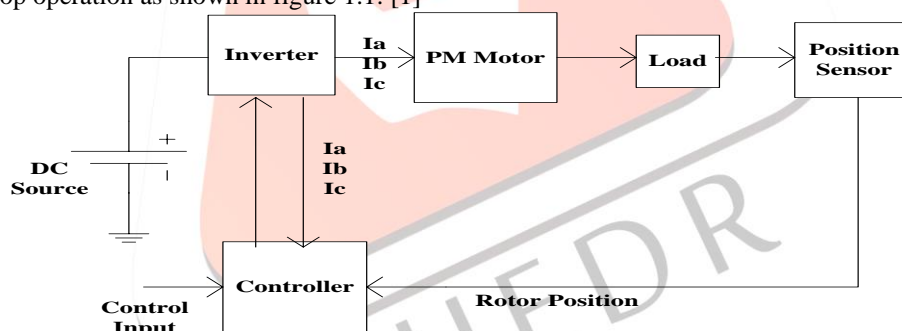


Figure 1.1 Closed loop PMSM Motor Drive.

II PROBLEM IDENTIFICATION

The PMSM used to build small power rating application devices such as Refrigerator, Washing Machine, House-hold appliances, Medical apparatus, Wide speed range of servo drives and industrial robots. PMSM drives are use for its high efficiency, fast dynamic response and small size etc. For the function of PMSM Drive first necessitate exchanging AC supply power to DC power with rectifier circuit and then DC power to variable magnitude and changeable frequency AC power to feed PMSM. PMSM works on two mode vector control mode as well as direct torque control mode of operation. At this time we are with vector control PMSM. Here for conversion of AC-DC we cannot use simple rectifier circuit which is shown in figure 1.2. Since in this circuit large value of capacitor is necessary which drawn a large value of small narrow pulse current. As we get the capacitor voltage distinction is nearly constant. But due to this current we obtain the supply voltage poor in conditions of high value of Total Harmonics Distortion low value of Power Factor Displacement Factor and poor Distortion Factor. These large harmonic currents not only produce distortion other than also create conducted and radiated Electromagnetic Interference. This difficulty becomes supplementary severe when all the strategy are organization in single phase supply [1-3].

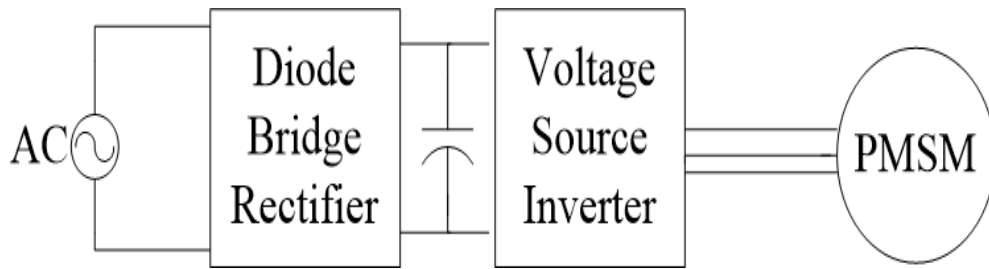


Figure 1.2 Basic Block Diagram of PMSM Drive directly connected with power supply.

III MODELLING OF VECTOR CONTROLLED PMSM DRIVE SYSTEM

Figure 1.2 shows the block diagram of the vector controlled PMSM drive system. It consists of control scheme with proportional plus integral (PI) speed controller, field weakening controller, d-axis current calculation, vector controller, Pulse Width Modulated (PWM) Current Controller (CC), voltage source inverter and PMSM.

1) *PI speed controller*: The input to the PI speed controller is the speed error $\omega_e(k)$ between reference speed $\omega_r(k)^*$ and the motor speed $\omega_r(k)$. This error is estimated at the with sampling instant as:

$$\omega_e(k) = \omega_r(k)^* - \omega_r(k) \quad (1)$$

The error is processed in the PI speed controller and the output of the controller is given by the reference torque Tk^* at kth sampling instant as:

$$Tk^* = T(k-1)^* + K_p\{\omega_e(k) - \omega_e(k-1)\} + K_i \omega_e(k) \quad (2)$$

Where K_p and K_i are the proportional and integral gains of the PI speed controller, respectively. After limiting the output of the PI controller (Tk^*) is taken as reference torque (T_{ref}).

2) *Reference winding current generation*: The quadrature, direct axis and three-phase reference motor winding currents are generated using the output of the speed controller and the rotor position. The following are the equations for the reference currents [4]:

The flux component of reference stator current (i_d^*) can be defined as:

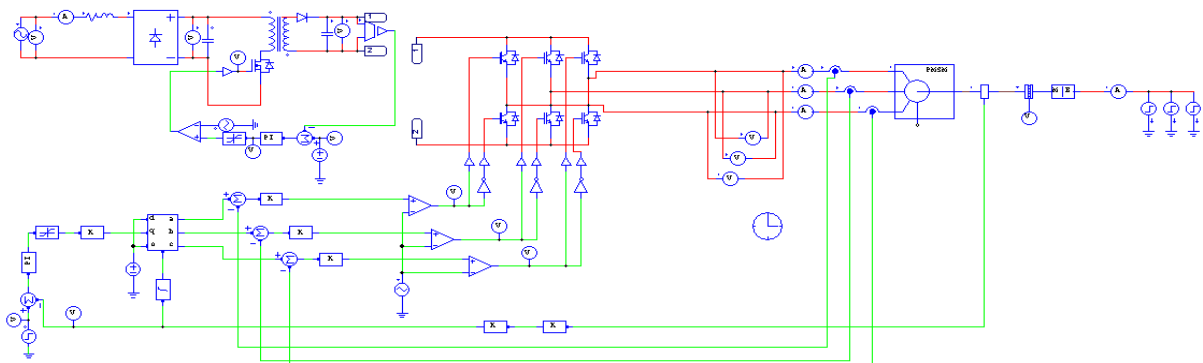
$$\begin{aligned} i_d^* &= 0 \text{ for } \omega_r < \omega_b \text{ and} \\ i_d^* &= \omega_f [\{\omega_b - \omega_r\} / \{\omega_r(L_d - L_q)\}] \text{ for } \omega_r > \omega_b \end{aligned} \quad (3)$$

The torque component of the reference stator current (i_q^*) can be obtained from reference torque (T_{ref}) as:

Where K_t is motor torque constant, L_d and L_q are q-axis and d-axis inductances and ϕ_f is the flux produced by rotor magnets of PMSM. The reference three-phase currents for the stator winding can be represented as:

Where θ_r is the rotor angular position in electrical rad/sec.

These reference currents ($i_a^* \ i_b^* \ i_c^*$) are compared with sensed winding currents ($i_a \ i_b \ i_c$) and the current errors are fed to the PWM current controller.



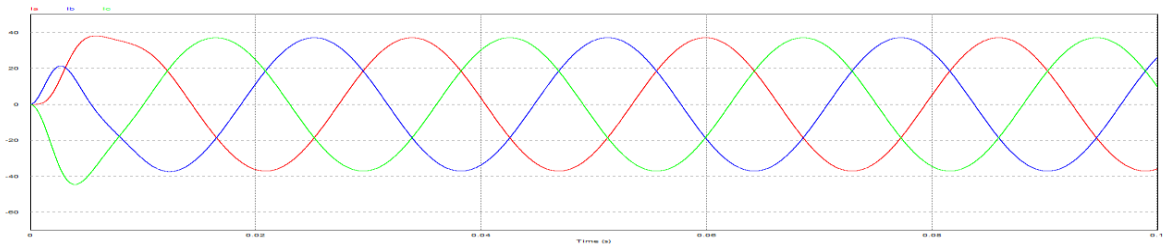


Figure 1.3 PSIM Simulation of PMSM Drive directly connected with Fly back converters.

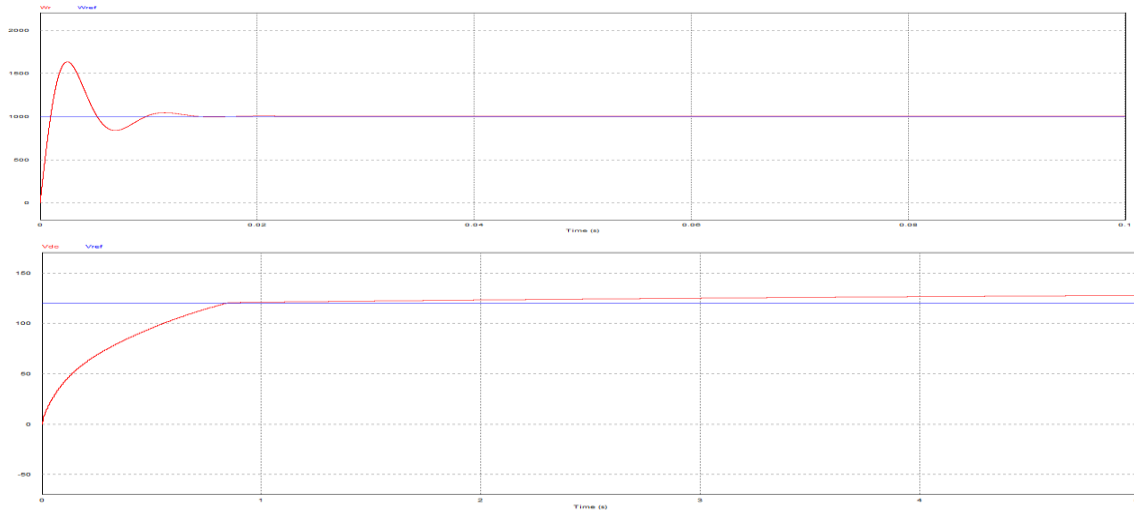


Figure 1.4 Output current, Reference speed, dc-link voltage.



Figure 1.5 s1 s2 s3 switching pulse of inverter.

After Simulation and Analysis of AC-DC Fly back Converter for Variable Speed PMSM drive for Power Quality Improvement, we get Total Harmonic Distortion of Supply current is varying from 12.6212% to 6.4318% for 20% to 100% load. [7-9]. Power Factor of PMSM with Fly back Converter Connected for 20% to 100% load is 0.991 to 0.998. The design and hardware implementation of the fly back converter for 12V, 5W output has been done. The universal switching mode power supply works properly for the input range of the 85 VAC to 265 VAC. As the input voltage varies from 85 VAC to 265 VAC, the output of the fly back converter is accurately maintained at 12 V. The Controller in the Feedback Loop ensures the constant output voltage of 12 V. The circuit is designed in such a manner that it can deliver a maximum current of 400mA.

TABLE I SIMULATION PARAMETER

SPECIFICATION AND INPUT DATA OF FLYBACK CONVERTER FED PMSM DRIVE SYSTEM		
Sr. No.	Parameter	Value
1.	Input Peak Voltage (V_s)	325V
2.	Output Voltage (V_{dc})	120V
3.	Rated Power of Converter (P_{in})	900W
4.	Switching Frequency of PWM Voltage Controller of Fly back Converter (f_s)	50kHz
5.	Rated Output Power of PMSM (P_{out})	600W
6.	Stator Resistance (R_e)	0.195Ω
7.	Inductance d-axis (L_d)	0.45mH
8.	Inductance q-axis (L_q)	0.45mH
9.	Back EMF Constant (K_0)	18.66V/KRPM
10.	Poles (P)	6

11.	Moment of Inertia (J)	0.000055Kg-m ²
12.	Static Friction (T _f)	0.14N-m
13.	Switching Frequency of PWM Current Controller of VSI (f _c)	10kHz
14.	PI Speed Controller Gains (K _p , K _i)	0.9, 0.0004
DESIGN PARAMETERS OF FLYBACK CONVERTER		
15	PI Voltage Controller Gain (K _{pdc} , K _{idc})	0.3,0.03
16	Voltage Ratio 'M'	0.3692
17	Turn Ratio of Transformer 'n'	4
18	Duty Ratio 'D'	0.1191
19	Conduction Parameter K	0.4190
20	Critical Value of Conduction Parameter of Converter 'K _{crit} '	0.30
21	Inductance L _m '	0.2mH
22	Filter Capacitance C _f	200nF
23	Output Capacitance C _{dc}	3000μF

TABLE II RESULT DATA

Sr. No	%Load	%THD of Is	Power Factor
1	20%	9.82	0.994
2	40%	7.23	0.995
3	60%	6.57	0.996
4	80%	5.41	0.997
5	100%	4.33	0.998

IV CONCLUSION

Application of Permanent Magnet Synchronous Motor drives are used owing to its high efficiency, fast dynamic response and small size. For the operation of PMSM Drive, AC provide is converted into DC supply using rectifier path and then DC supply is converted addicted to variable magnitude and variable frequency AC supply with help of inverter to feed PMSM. High value of Total Harmonics Distortion (THD), low value of Power Factor (PF), Displacement Factor (DPF), and poor Distortion Factor (DF) are some problems of using simple rectifier circuit. These problems can be reduced by using Fly back converter. The Fly back converter be able to be use in either in CCM or DCM but if converter is used in CCM mode then it cannot sustain current stress as it can be sustained in DCM mode. PMSM operates on two modes - vector control mode and direct torque control mode. In this thesis, Simulation and Analysis of vector controlled PMSM using AC-DC Fly back Converter in DCM mode is done for power quality improvement. The single switch topologies can be preferred in sequence of fly back, Zeta, Cuk, and SEPIC converter. Because Zeta and fly back converter topologies provide additional protection beside in excess of current and inrush current as compare to Cuk and SEPIC converter topologies. Furthermore, the fly back converter topology require only a capacitor as an output filter and the Cuk converter topology requires smaller core, and has lower core and copper losses.

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