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An Improvement of Power Quality in Multi-Output Forward Boost Converter

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***Abstract*-- DC-DC converters are the core of any exchanged mode control supply (SMPS) framework. Instead of utilizing different quantities of DC-DC converters for controlling voltage of each of the yields in a multi-yield SMPS, the unwavering quality and cost viability can be enhanced if a solitary DC-DC converter is utilized and suitable control system is utilized to manage the voltages adequately. This paper manages such a multi-yield SMPS of 175W rating, regularly utilized as a part of a (PCs), utilizing forward lift converter. An exertion is made to enhance the information control quality additionally at the utility interface by utilizing normal current control mode. The impact of load variety and info supply minor departure from SMPS is concentrated to exhibit the execution and viability of this converter in directing the yields in the extensive variety of mains voltage.**

***Index Terms*-- Forward boost converter, SMPS, Power factor correction, Power quality, Efficiency**

I. INTRODUCTION

Efficiency, size and cost are the essential focal points of exchanging power supplies contrasted with straight supplies because of which the last are getting to be noticeably outdated nowadays. The exchanged mode control supplies (SMPS) showcase is quickly developing because of quickly expanding utilization of electronic hardware, for example, PCs, telephones and net-books that are getting to be noticeably ordinary [1-2]. As the innovation creates, incorporated circuits (ICs) work quicker and get littler in measure. This calls for control supplies with littler misfortunes so the warmth can be scattered in littler surface region itself and consequently SMPS are on request. Multi-yield SMPSs are utilized as a part of (PCs) and shopper electronic machines. To enhance control factor of these SMPSs, a power factor revision (PFC) circuit is set before the converter, which thus is interfaced with the heap. It forms the power such that it stores the info vitality when it is bigger than the dc yield power, and discharges the put away vitality when the information control is not as much as the required dc yields control. To achieve the above procedure, no less than one vitality stockpiling component must be incorporated into the PFC circuit. It powers the air conditioner line current to take after the information line voltage with the end goal that the solidarity control factor can be acquired at air conditioning mains.

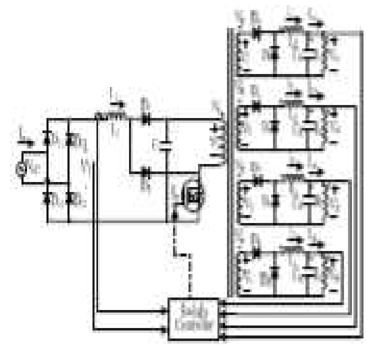

Fig.1. Circuit configuration of multi-output forward boost converter

arrange consonant voltage. At the point when the switch Sw is on, the diode D2 ends up noticeably forward one-sided making diode D1 turn around one-sided. At the point when turn kills, diode D1 winds up plainly forward one-sided and the vitality is exchanged to the heaps. A metal oxide field impact transistor (MOSFET) is utilized as the exchanging gadget for on/off control of the converter. High exchanging recurrence brings about a quick control of yield DC voltages and powerful PFC activity bringing about decrease in size of magnetic and channels. The exchanging recurrence is chosen by different factor, for example, the constraints of the exchanging gadget, its exchanging misfortunes and working influence level. Weighted blunder approach is utilized to manage every one of the yields as appeared in Fig. 2. The weighting component of each of the yields is increased with the individual yield blunders, and their whole is gone through a PI controller to choose Idc. A yield swell channel is likewise intended for the multi-yield DC-DC converter to lessen the swells acquainted due with high exchanging recurrence fsw.

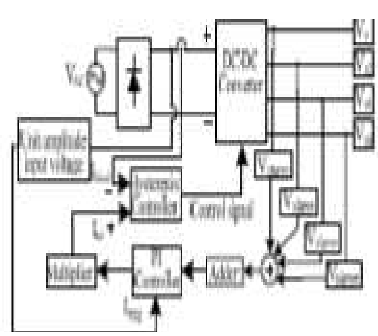

Fig. 2. Control scheme for the SMPS

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III. DESIGN OF PFC FORWARD BOOST CONVERTER

The forward boost converter is designed with an objective of power quality improvement at AC mains. The boost converter topology is commonly used in industries as the output voltages are greater than AC supply. The SMPS consists of a diode bridge, isolated multi-output forward boost converter and output ripple filters. For the design it is assumed that passive components are linear, time invariant and frequency independent. The switching frequency is much higher than line frequency so that averaged quantities over a switching cycle can be considered in place of instantaneous quantities. The HFT leakage inductance and stray capacitance are considered to be negligible. Further, the current through the inductor Lo is assumed to be linear. The forward boost converter controls the DC link voltage at a set reference value. The relationship between output and input is given as, Vo1/Vd=1/{n(1-D)} (1) where n is the ratio of Ns1/Np. Ns1 is the number of turns in secondary windings of the HFT and Np is the number of turns in secondary windings of the HFT. D is the duty ratio of the converter which is an important parameter to decide the on off time of the switch Sw. Vo1 is the output voltage of the highest rating secondary winding. Due to high frequency the output voltage and input current have ripples. So, a ripple filter is designed for constant output voltage with inductance (L2) and capacitance (Co1) so that the peak to peak ripple of inductor current (_IL2) and capacitor voltage (_VCo1) are maintained
within specified value for the given switching frequency (fs). An inductance L1 value can be calculated for a given current ripple is given as,
L1=VdDT/_iL1 (2)
Similarly inductor L2 value can be calculated for a given current ripple as,
L2= -Vo1(1-D)T/_iL2 (3)
The values of output filter capacitor is calculated as,
Co=Io/(2__Vo) (4)
where Io is output current of the converter, _Vo is the ripple in output voltage.
_=2_f, f being the fundamental frequency.

IV. DESIGN EXAMPLE

Designing of the forward boost converter is presented in this section through a design example. The converter can be viewed as a single-phase single switch multi-output DC-DC converter. A forward boost converter with the following specifications is designed to illustrate the design procedure: input voltage is Vin= 220V (rms), 50 Hz, output voltage Vo1= 5V, Vo2= 12V, Vo3= -5V, Vo4= -12V, output power Po=175W, switching frequency fSW= 50 kHz, Ts=20_s, Output voltage ripple _Vo= 2%, ripple current _iL= 2%, the nominal duty ratio of the switch D= 0.45. The input voltage to the isolated forward boost converter, Vd=198V. Using eqn. (1) the HFT ratio 'n' is calculated as, n1=0.0138, n2=0.0333, n3=0.138, n4= 0.0333 The value of the input inductor L1 can be calculated from eqn. (2) as, (_iL1)ripple =5% of the input current Iin=0.9A, therefore the L1 value is 39.6Mh The value of the output filter inductor L2 can be calculated
from eqn. (3) as, (_iL2)ripple =2% of the input current Io1=18A, therefore L2 value is 0.15mH
Similarly, (_iL3)ripple= 0.04, (_iL4)ripple=0.006, (_iL5)ripple=0.016 So the value of L3= 3.3mH, L4=9.16mH, L5=8.25mH The value of the capacitor Co1 can be calculated from eqn. (4)
_Vo1=2% of the output voltage Vo1=5V, therefore (_Vo1)ripple= 0.1V as, Co1= 286mF Similarly Co2= 39mF, Co3= 4.7mF, Co4= 5.3mF. These designed components values have been considered while modeling the forward boost SMPS system.

V. EFFICIENCY OF FORWARD BOOST CONVERTER

The efficiency of the multi-output forward boost converter is approximately calculated by considering the individual losses in the SMPS as estimated below. The SMPS basically consist of bridge rectifier, multi-output forward boost, HFT and output diodes and filters. Efficiency (%) = Total output power/(Total output power +Total Losses in the converter) Total losses are as, Total Loss = Losses in diode bridge rectifier + losses in multioutput forward boost converter + losses in hft + losses in output diodes.

VI. SIMULATION OF MULTI-OUTPUT FORWARD BOOST CONVERTER

The simulation diagram of multi-output forward boost converter fed SMPS along with the control circuit is simulated in PSIM environment, as shown in Fig. 3. This model shows a single-phase supply of 220V, 50Hz connected to the diode bridge which is in turn connected to the forward boost converter. The forward boost DC-DC converter is connected to the HFT. The HFT has four secondary windings namely Ns1, Ns2, Ns3, Ns4 which are connected to the outputs Vo1, Vo2, Vo3 and Vo4 respectively. The output voltage is regulated by a PI (Proportional-Integral) controller using weighted error approach. A low pass filter is used at the output side to filter out the harmonics. The input currents/voltages, output currents/voltages during source and load variations are shown in Figs. 4-6. Tables I and II present the simulation results at source and load variations. The simulation results for the converter are described in the following section.

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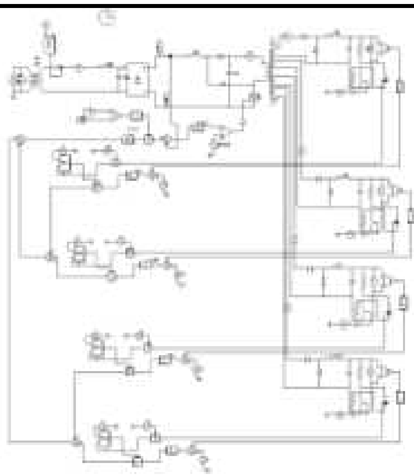

Fig. 3. Simulation diagram of forward boost converter

VII. RESULTS AND DISCUSSION FOR FORWARD BOOST CONVERTER

The simulation of the multi-output forward boost converter has been carried out for assessing its performance under load variations and supply voltage variations. The start-up performance and response to load and supply voltage variations have been studied and presented in Figs. 4-6. Fig. 4(a)-(d) shows the response of the converter at the input voltage of 220V. It is seen from Fig. 4(b) that under normal supply voltage conditions, it takes about 7 cycles for the voltages to settle down initially. The +5V output load is varied from 100% to 50% at 0.4 sec. Table I summarizes the output voltage ripple, THD, PF and DPF of the forward boost converter at 100% and 50% load conditions with 220V mains voltage. Table II shows the performance of the converter for supply voltage variations. The time taken by the output voltages to settle down initially diminishes as the supply voltage increases. For example, at 220V, it takes 7 cycles for settling down, whereas at 270V, it is about 5 cycles. All the outputs settle down to their respective values with a 2% ripple. When a load disturbance is given in +5V output at 0.4 sec (from 100% to 50% load), the outputs settle to their original

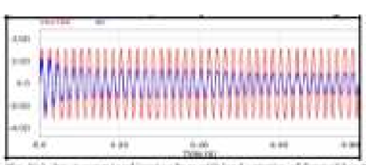

Fig. 4(a). Input current and input voltage with load variation of forward boost converter at 220V

Fig. 4(b). Output voltage with load variation of forward boost converter at 220V.

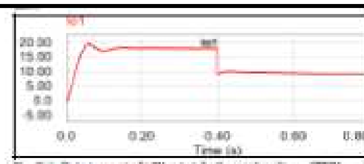

Fig. 4(c). Output current of +5V output for the supply voltage of 220V.

Fig. 4(d). THD spectrum of the forward boost converter

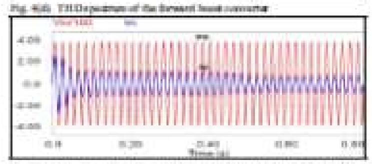

Fig. 5(a). Input current and input voltage with load variation of forward boost converter at 270V.

regulated values within a matter of 1.5 cycles of supply voltages of 220V, 170V and 270V respectively. The mains current remains sinusoidal for full-load as well as 50% load conditions with the power factor being unity. In all the cases the THD of the input current is below 10%, which is very much within the specifications of IEEE-519 standard. Fig. 5(a)-(c) shows the response of the converter when the input voltage changes to 270V. The +5V supply has more overshoot than that observed at 220V. The current and voltage remain sinusoidal for full-load and light load conditions with PF being maintained close to unity. Fig. 6(a)-(c) shows the response of the forward boost converter at 170V. Here again, the load disturbance is introduced at 0.4 sec in +5V supply. The THD of the mains current is well within 10% and the PF is close to unity for different load conditions of the +5V output. From the Table III, it is clear that the PF and THD have marginally improved due to an increase in the input current owing to the reduction in input voltage Vin. The mains current at full-load are 0.88A, 0.744A and 1.17A at mains voltages of 220V, 270V and 170V respectively.

Fig. 5(b). Output voltage with load variation of forward boost converter at 270V

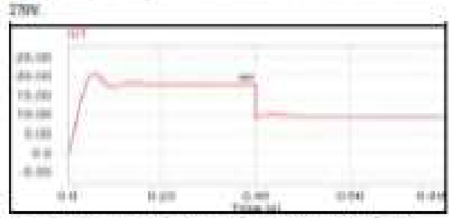

Fig. 5 (c). Output current of +5V output for the supply voltage of 270V

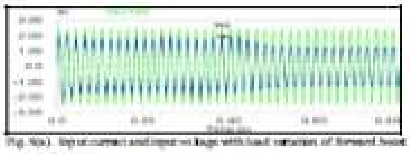

Fig. 9(a). Input current and input voltage with load variation of forward boost converter at 170V

Fig. 9(b). Output voltages with load variation of forward boost converter at 170V

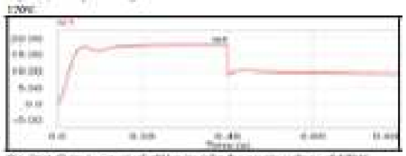

Fig. 9(c). Output current of +5V output for the supply voltage of 170V.

TABLE I
CONVERTER PERFORMANCE UNDER 100% LOAD AND LOAD DISTURBANCE AT 220 V

Converter topology	Power supply Specifications	Output Voltage Ripple		THD		Power factor		DPF	
		100% load	50% load	100% load	50% load	100% load	50% load	100% load	50% load
Forward boost Converter	[illegible]	1.7%	1.8%	5.4	8.2	0.994	0.998	0.998	0.994
	+12V/6A	1.9%	1.9%						
	-5V/0.3A	1.4%	1.7%						
	-12V/0.8A	1.8%	1.9%						

TABLE II
CONVERTER PERFORMANCE UNDER 100% AND 50% LOAD WITH INPUT SUPPLY VARIATION

Input Voltage	THD		Power factor		DPF		Input current(A)		
	100% load	50% load	100% load	50% load	100% load	50% load	220 (V)	270 (V)	170 (V)
270V	7.5	8.3	0.995	0.998	0.995	0.994	[illegible]	[illegible]	1.17
170V	5.9	8.5	0.996	0.995	0.999	0.994			

VIII. CONCLUSION

A comprehensive execution investigation of a multi-yield forward lift converter connected to a SMPS framework has been done in this paper for changing burden and supply voltage conditions. An entire outline technique additionally has been given an illustration. The reaction of the framework has been gotten amid start up and stacks bother. The execution parameters of the framework regarding its info control quality and yield voltage direction have been examined. It is discovered that the THD of the information current falls inside 10% for both full-stack and in addition half load for the total scope of working voltage of the mains from 170V to 270V with the power factor being kept up near solidarity. The voltage swells at all the yields are additionally monitored meeting the necessities of being inside 2%. Taking all things together, this paper has exhibited a successful outline of a multi-yield SMPS utilizing a solitary forward lift converter with enhanced information control quality and yield voltage direction.

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