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Active Power Factor Correction for LED Lamp Driver

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***Abstract* - Traditionally conversion of ac to de voltages has been dominated by phase controlled or diode rectifiers. The non-ideal character of the input current drawn by these rectifiers creates number of problems like increase in reactive power, high input current harmonics and low input power factor, lower rectifier efficiency, large input voltage distortion etc. To compensate for the higher reactive power demand by the converters at high power transfer levels, power factor correction becomes mandatory. Phase controlled converters are widely used because these converters are simple, less expensive, reliable, and do not require any commutation circuit. However, the SPF in phase-controlled converters is low when the output voltage is less than the maximum, that is, when the firing angle is large. As the firing angle increases, the displacement angle between the supply voltage and current increases and the converter draws more lagging reactive power, thereby decreasing the PF. Semi-converter systems provide better PF than full-converter systems, although the improvement is not remarkable. This poor PF operation is a major concern in variable speed drives and in high power applications. Better electrical utilization and efficiency can be achieved with the use of PF improvement system. This is the area we have identified to work. Our efforts will be in the direction towards increasing the active power and to reduce reactive power. Thus in turn PF will be improved. A novel digital and analog power factor correction techniques for single phase boost converter using pulse width modulation. It attempts to bring the input voltage waveform and input current waveform in phase with each other. In digital technique, switching is carried out using digital signal processor TMS320F2812. In analog technique, it is implemented using IC UC3854.**

Keywords: Power Factor Correction (PFC), LED driver, phase controlled converters, IC UC3854.

I. INTRODUCTION

Power factor is the ratio between the KW and the KVA drawn by an electrical load where KW is the actual load power and KVA is the apparent load power. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system. The power factor is determined by the type of loads connected to the power system. These can be 1. Resistive 2. Inductive 3. Capacitive if a purely resistive load is connected to a power supply, current and voltage will change polarity in phase, the power factor will be unity (1), and the electrical energy flows in a single direction across the network in each cycle. 9 Inductive loads such as transformers and motors (any type of wound coil) generate reactive power with current waveform lagging the voltage. Capacitive loads such as capacitor banks or buried cable generate reactive power with current phase leading the voltage. Both types of loads will absorb energy during part of the AC cycle, only to send this energy back to the source during the rest of the cycle. Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor (PF) that is less than 1. PFC can reduce the harmonics in the line current increase the efficiency and capacity of power systems and reduce customers' utility bills. Power factor correction may be applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network. Or, correction may be installed by individual electrical customers to reduce the costs charged to them by their electricity supplier we can follow different methods of improving power factor 1) Passive method 2) Active method.

II. METHODOLOGY

Fig. 1 shows the block diagram of analog technique using IC UC3854. The power circuit of an analog technique comprises of a rectifier, an input inductor, a switching device, unidirectional diode, output capacitor and the load. In analog technique the power factor is improved by comparing the output voltage with a reference voltage which in turn is compared to the standard voltage generated by multiplying rectified voltage and the input current thereby improving the power factor by correcting the error and making input voltage and current in phase.

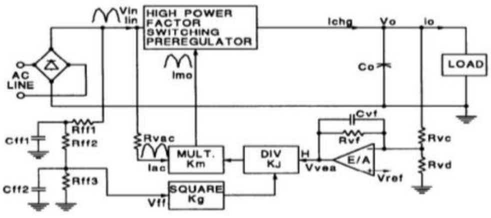


Figure 1: System Architecture

Analysis of the power stage design in analog circuit makes use of a boost converter. The control circuit for a boost power factor corrector does not change much with the power level of the converter. The power stage will be different but the design process will remain the same for all power factor corrector circuits. Since the design process is identical and the power stage is scalable, the corrector serves as model example and it can be readily scaled to higher or lower output levels. The choice of switching frequency is generally somewhat arbitrary.

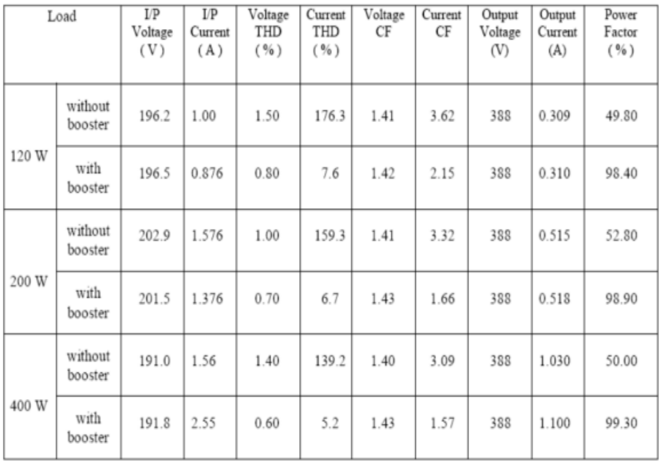
The switching frequency must be high enough to make the power circuits small and minimize the distortion and low enough to keep the efficiency high. In most applications, a switching frequency in the range of 20 KHz to 300 KHz proves to be an acceptable compromise. The value of the inductor would be reasonably small and cusp distortion minimized, the inductor would be physically small and the loss due to the output diode need not be excessive. Converters operating at higher power levels may find a lower switching frequency desirable to minimize the power losses.

The inductor determines the amount of high frequency ripple current in the input and its value is chosen to give some specific value of ripple current. Inductor value selection begins with the peak current of the input sinusoid. The maximum peak current occurs at the peak of the minimum line voltage and is given by: $Ilin(\mathrm{pk}) = (\sqrt{2} \times PVin(\mathrm{min}))$ (1) where, P is Input Power The maximum ripple current in a boost converter occurs when the duty factor is 50% when the boost ratio M = $VoVin$ = 2 The peak value of inductor current generally does not occur at this point since the peak value is determined by the peak value of the programmed sinusoid. The peak value of inductor ripple current is important for calculating the required attenuation of the input filter. The peak-to-peak ripple current in the inductor is normally chosen to be about 20% of the maximum peak line current. A larger value of ripple current will put the converter in the discontinuous conduction mode for a larger portion of the rectified line current cycle. This means that the input filter must be larger to attenuate more high frequency ripple current. The value of the inductor L is selected from the peak current at the top of the half sine wave at low input voltage, the duty factor D, at that input voltage and the switching frequency is given by, $Lm = Vin \times Dfs \times \Delta I$ (2) where $Do = Vo - VinVin$ 18 ΔI is Peak-to-Peak ripple current.

III. RESULTS AND CONCLUSION

Table 1 shows the results carried out with the circuit, which is tested at various load conditions. It is observed that even though the load varies the output voltage remains constant and the power factor varies from 0.984 to 0.993.

Table 1: Test Results for Various Load Conditions



Load		I/P Voltage (V)	I/P Current (A)	Voltage THD (%)	Current THD (%)	Voltage CF	Current CF	Output Voltage (V)	Output Current (A)	Power Factor (%)
120 W	without booster	196.2	1.00	1.50	176.3	1.41	3.62	388	0.309	49.80
	with booster	196.5	0.876	0.80	7.6	1.42	2.15	388	0.310	98.40
200 W	without booster	202.9	1.576	1.00	159.3	1.41	3.32	388	0.515	52.80
	with booster	201.5	1.376	0.70	6.7	1.43	1.66	388	0.518	98.90
400 W	without booster	191.0	1.56	1.40	139.2	1.40	3.09	388	1.030	50.00
	with booster	191.8	2.55	0.60	5.2	1.43	1.57	388	1.100	99.30

Figure 1 shows voltage and current waveforms without booster (without application of proposed PFC scheme) and Fig. 6.2 shows voltage and current waveforms with booster (with proposed PFC scheme) at the load of 120 Watt. It can be observed that the power factor improves from 48.80% to 98.40%. Fig. 6.3 shows voltage and current waveforms without booster and Fig. 6,4 shows voltage and current waveforms with booster at the load of 400 Watt. The power factor varies from 50.00% to 99.30%. Harmonic analysis is also carried out using power analyzer at load 400 Watt. Fig 7.1.shows the harmonic analysis, where fundamental component is observed as a dominant where as all other frequency components are suppressed.

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