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Plug-In Hybrid Electric Vehicle Battery Chargers Using a Single-Phase PFC Converter

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***Abstract**: The authors introduce an ac–dc front-end power factor correction solution for PHEV battery charging operations. The system design enables accurate dc output delivery and minimizes harmonic content in the ac input and improves power quality through power factor regulation. The research introduces a boost converter topology which operates in continuous conduction mode to minimize significantly input current harmonics. The system achieves digital power factor correction by implementing control functions through an inexpensive digital signal controller.*

The research continues with theoretical and experimental implementation of the suggested converter and its control methodology through digital control system development. A detailed approach for converter operation and universal ac input voltage control from 150–340V to produce 480V dc output at 5.0 kW load is described using both theoretical and experimental measurement data with a power factor surpassing 0.84. Experimental findings show that the new control approach provides plug-in hybrid electric vehicle (PHEV) battery charging applications with both advantageous features and operational flexibility.

***Keywords**: Microcontroller, fuzzy logic, hybrid electric car, Power factor adjustment and power converter*

I. Introduction

AC to DC power conversion stands as a core technology which serves battery energy storage units as well as switch-mode power supplies and adjustable-speed drives and uninterrupted power supply (UPSs). A common approach to building rectifiers as ac–dc converters consists of employing diodes and thyristors to create unidirectional and bidirectional power flow through uncontrolled and controlled dc power. Hybrid electric cars qualify as a type when their rechargeable storage units accept exterior electric power through external connectors. Shortened terms for this vehicle category exist as PHEV.

The dc to dc converter equipped with input and output EMI filters stands as the conventional power system design for chargers according to [4]. Sine wave inputs cause capacitors to extract pulse current spikes which then flow to rectified voltage sources. Every equipment connection to the system produces brief discontinuous electrical currents without affecting their nature. The essential function of a rectifier using capacitive filtering emerges when dipolar voltage sources are required for various applications. The irregular pattern of the short-term electrical current surge results from this effect. Network losses along with overall harmonic content and radiated emissions greatly increase during the extraction of this current type from the mains supply.

The main objective of this study demonstrates PFC design implementation for plug-in hybrid electric vehicle chargers using an economical microcontroller system. The article details how an 8-bit microcontroller fulfills the software needs vital for PFC implementation. Fuzzy logic rules powered the control mechanism which improved the performance output of the proposed converter. Multiple important waveforms together with test results successfully validate the digital implementation of PFC converter implementation. A monolith electronic controller enables affordable digital hardware development for PHEV chargers along with its performance potential and ADC and PWM peripherals.

II. Boost Topology

The ratio between working power consumption and apparent total power shows as power factor in power systems. The power factor determination results in substantial budget savings which makes it an essential measurable amount. The primary mission of PFC is to present the input of power supplies as though they function as simple resistors. The power distribution system operates more efficiently because of this energy reduction possibility.

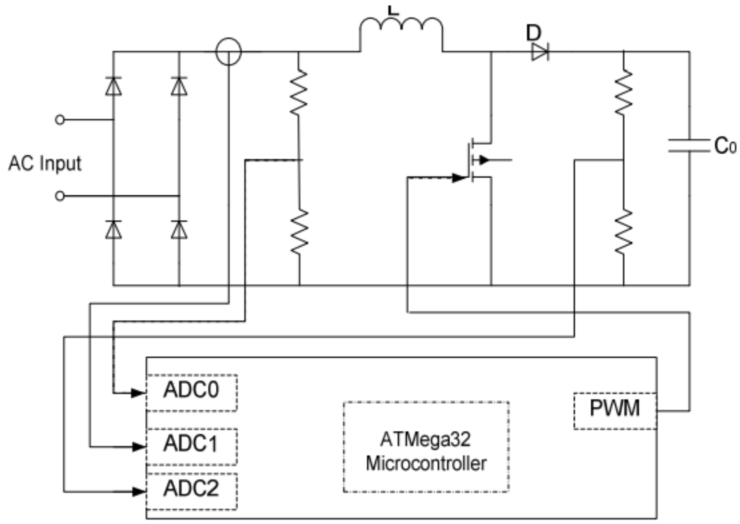

Fig 1: Proposed boost PFC converter

A boost topology PFC converter elevates the input voltage and forms the inductor current after rectified AC voltage. Proper voltage operation for the power switch matches directly with the basic output voltage standards set for the converter. The basic boost converter functions according to the circuit diagram displayed in Fig. 1. The Boost topology PFC converter can operate in Continuous Conduction mode which stands as a capability unavailable for both buck converter and buck-boost converter in their fundamental states.

This operational mode reduces the frequency spectrum of harmonic currents present at the input terminal. The continuous conduction region function requires values from both the inductor and system load parameters. The active PFC controls both the input current as well as the output voltage. Since the rectified line voltage controls current waveforms, the converter maintains a resistive-like input behavior. The proper management of output voltage is possible by modifying the programming signal's average amplitude. A real load's power requirements cause the effective resistance to vary smoothly while demanding proper specification of the resistive load connected to the AC line. The alternating voltage and current always stay directly proportional to one another.

III. PFC Software Implementation

A control block implements its outer loop to create the voltage loop. The reference DC voltage VDCREF and the actual measured output DC voltage VDC serve as the voltage loop's inputs. A control output from the voltage error compensator must function to retain VDC at Vdcref independent of variations in VAC or IO. The inner current loop reference current IACREF is established through the control output of the voltage controller GV as shown in Figure 2.

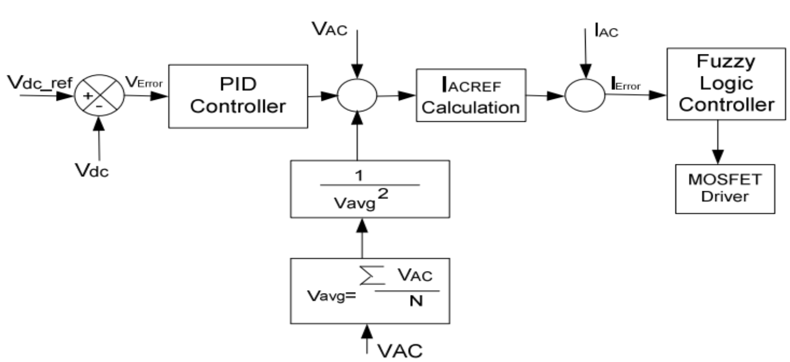

Fig 2: PFC software implementation

IV. Fuzzy Control System

A control block establishes its outer loop to develop a voltage loop. The reference DC voltage V_{DCREF} and the actual measured output DC voltage V_{DC} serve as the voltage loop's inputs. The control output produced by the voltage error compensator enables V_{DC} to stay at V_{dcref} even when V_{AC} or I_O changes. The voltage controller GV generates I_{ACREF} as its control output through inner reference current feedback as visualized in Figure 2.

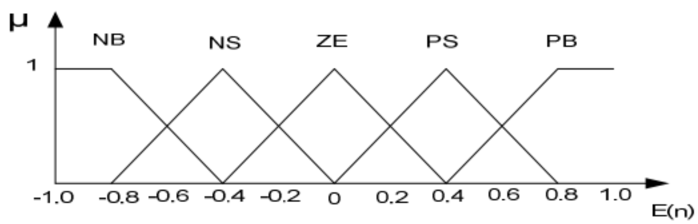

Fig 3: The relationship between linguistics variable and error

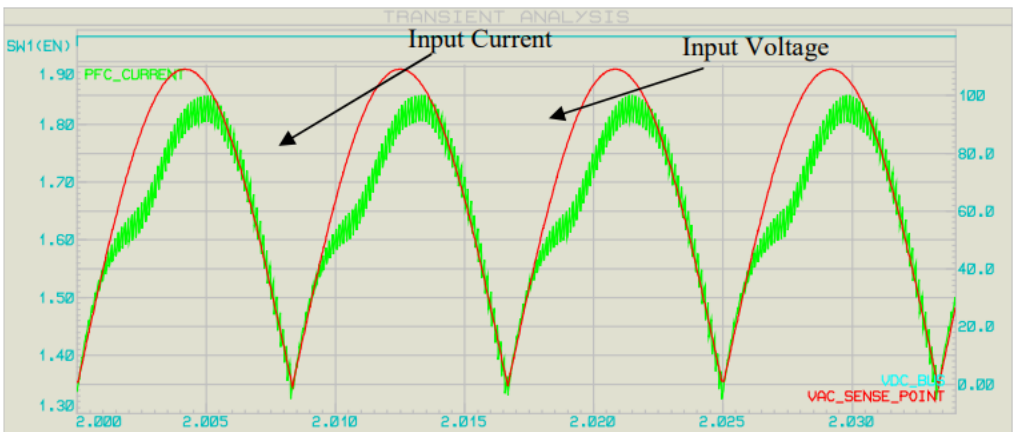

Fig 4: Rectified Input voltage and input current

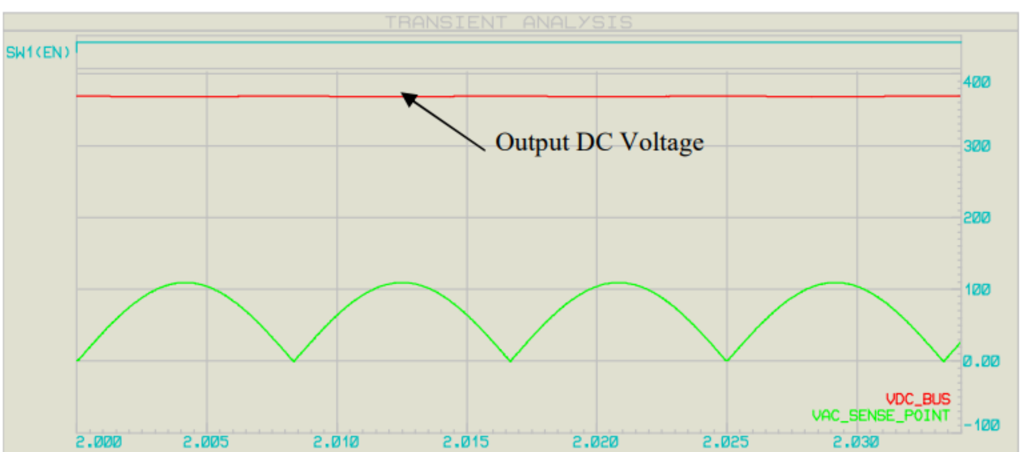

Fig 5: Output voltage and rectified input voltage

V. Conclusion

The research outlines a PFC based AC-DC boost converter design for PHEV battery charger front-end AC-DC converters. The research explores analysis and performance evaluations of the proposed converter structure. The proof-of-concept was verified by conducting simulations with a microcontroller. The system performed well according to measurements of its regulated output dc voltage and power factor and total harmonic distortion. The converter topology demonstrates superior input current harmonics alongside a high input power factor together with good efficiency throughout its complete load range. The plug-in hybrid electric vehicle charger application uses this combination as a perfect single phase PFC solution.

References

[1] Juan Paulo Robles Balestero, Fernando Lessa Tofoli, Rodolfo Castanho Fernandes, Grover Victor Torrico-Bascopé. Power Factor Correction Boost Converter Based on the Three-State Switching Cell. IEEE Trans. Industrial Electronics, Vol.59, No.3, March 2012, pp 1565-1577.

[2] K.Morrow, D.Karner,and J.Francfort. Plug-in hybrid electric vehicle charging infrastructure review. U.S. Dept.Energy—Vehicle Technologies Program, Washington, DC,INL-EXT-08-15058,2008.

[3] B.Singh, B.N.Singh, A.Chandra, K.Al-Haddad, A.Pandey, and D.P.Kothari. A review of single phase improved power quality AC–DC converters. IEEE Trans. Ind. Electron.,vol.50,no.5,pp.962–981, Oct. 2003.