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Contents

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A two-switch multi-input step-up DC/DC converter for PV systems

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Abstract— This study presents a new two-switch multi-input high step-up DC/DC converter. A coupled inductor is used to enhance the voltage gain. Having a bidirectional port makes the converter suitable for applications in need of battery such as stand-alone photovoltaic (PV) systems. As a result, the proposed converter has the merits of integrating two power sources along with boosting the input voltage. Furthermore, in comparison with typical three-port DC/DC converters which utilize three switches, the presented converter employ only two switches to control the converter. Hence, cost and size of the structure is reduced. In order to verify the performance of the converter, simulation results are taken and depicted.
Keywords— multi-input, DC/DC converter, high step-up, stand-alone PV systems, maximum power point tracking (MPPT) algorithm.

I. INTRODUCTION

Currently, a great proportion of electricity used around the world is generated by burning fossil fuels such as gas and coal. This makes the electricity sector one of the biggest contributors to greenhouse emissions. On the other hand, the sources of fossil fuels are limited and going to be used up completely in near future. Aforementioned problems along with capability of renewable energy resources in generating electricity have lead the governments and researchers to increase the contribution of them in electric production. Among these resources, PV systems have noticeable features including noiseless function, no pollution, vast scale availability and low maintenance cost [1]. However, intermittent feature of PVs is one of their main drawbacks. Hence, PV systems are accompanied with an energy storage system (ESS) to balance the power between PV modules and load in stand-alone renewable power system applications [2]. One feature that must be taken into account in designing the interface converter for PV systems is the bidirectional power flow capability of storage element port. In conventional systems, multiple individual converters have been used for each power supply (either unidirectional or bidirectional). Nowadays, compared to typical structures, multi-input converters (MICs) offer a compact converter with centralized control, higher reliability and efficacy, lower size and cost reduction [3]. In recent literature, a number of works have been reported in designing a compact converter which could integrate two power supplies to the utility grid or load [4-5]. A compact three port DC-DC converter is studied in [4]. One of the merits of the presented converter is having a bidirectional port which makes it suitable for applications in need of battery. Moreover, the number of utilized elements is reduced in comparison with conventional structures. However, low voltage ratio of the converter makes it unsuitable in high voltage gain applications. In [5], an isolated three-phase high step-up DC-DC converter is used for integrating renewable energy resources into the grid or load. By the use of three-phase high frequency transformer, high voltage gain is achieved. The converter utilizes only three switches which results in a higher efficiency. However, another converter is needed to connect the battery to the DC bus. A compact two-input converter is proposed for standalone PV systems in [6]. Moreover, high voltage gain of the converter makes the converter suitable for low input voltage applications. However, the high number of semiconductors and passive elements reduce the efficiency.

This paper presents a novel two-switch high step-up multi-port DC-DC converter to integrate stand-alone PV system and battery unit into the DC bus. Compared to conventional multi-ports which use at least three switches to hybridize a power source and a battery, the proposed converter has only two switches. Hence, cost and size of the converter is significantly reduced. Meanwhile, high step-up capability of the converter makes it a promising converter for power supplies with low output voltage, such as PVs. Performance of the converter in three states including no battery, battery charging and battery discharging is analyzed. The rest of the paper is devoted as followings. In the next section, analysis of the converter is given. Employed power management method is described in Section III. In section IV, simulation results are depicted. Finally, section V concludes the whole paper.

II. OPERATION PRINCIPLES

A) Circuit Principles

The structure of proposed converter is shown in Fig. 1. The circuit consists of two power switches, five diodes, three capacitors and one coupled inductor. Vi is the primary input and battery is assumed as second input. Coupled inductor is modeled as magnetize inductor Lm, leakage inductor Lk and an ideal transformer N_2/N_1. In order to simplify the circuit analysis, following assumptions are taken:

1) The proposed converter is analyzed in continuous conduction mode (CCM).
2) Capacitors C_1, C_2 and C_o are large enough and voltage across them are considered as constant voltages.
3) Turn ratio of transformer N_2/N_1 is assumed as n.
4) The power switches and diodes are ideal.
5) The coupling coefficient of the couple inductor k equals to Lm/(Lm+Lk).

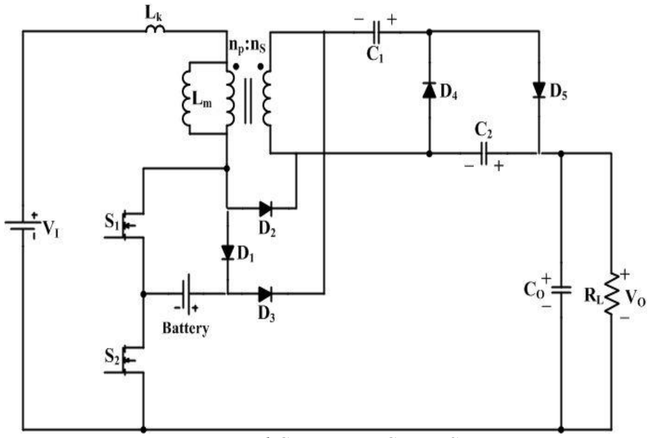


Fig. 1. *Proposed Converter's Circuit Structure*

B) Operation States

The proposed converter can operate in three different states which are described in followings:

1) Single input: Main power source supplies the load and battery is not connected.
2) Battery charging: Main power source supplies the load and battery is charged.
3) Battery discharging: Main power source supplies the load and battery is discharged.

First State (Single input): In this state, V_i furnishes the load without the battery. This state consists of five operation modes (Fig. 2.).

Operation mode I [t_0-t_1]: This operation mode begins at t_0 by turning switches S_1 and S_2 on. Diode D_4 conducts and other four diodes are off. The load is supplied by output capacitor C_o and input source charges the coupled inductor. This mode ends when the current of secondary windings of coupled inductor reaches zero.

Operation mode II [t_1-t_2]: This operation mode begins at t_1, when diode D4 turns off with ZCS. During this state, current of leakage inductor is bigger than current of magnetizing inductor. Diode D5 is on and others are off. The load is supplied by output capacitor C_o and input source charges the coupled inductor. This mode ends when switches S_1 and S_2 are turned off.

Operation mode III [t_2-t_3]: By turning switches S_1 and S_2 off, diode D_2 will be turned on. Since the currents of primary and secondary sides of coupled inductor is not equal, clamp diode D_2 conducts and the stored energy in leakage inductor is transmitted to the output load. During this mode, diode D_5 conducts and diodes D_1, D_3 and D_4 remain off. This mode ends when the current of secondary windings reaches zero.

Operation mode IV [t_3-t_4]: in this mode, switches S_1 and S_2 are off and diodes D_1, D_2 and D_3 conduct. Diodes D_4 and D_5 are off. During this mode stored energy in capacitor C2 is transmitted to the output. This mode ends when switch $S_1$is turned on.

Operation mode V [t_4-t_5]: This mode begins when diode D_2 turns off with ZCS and continues until switches S_1 and S_2 are turned on. Diodes D_1, D_2 and D_4 are off. During this mode energy of input source, coupled inductor and capacitor C_2 is transmitted to the output load and capacitor.

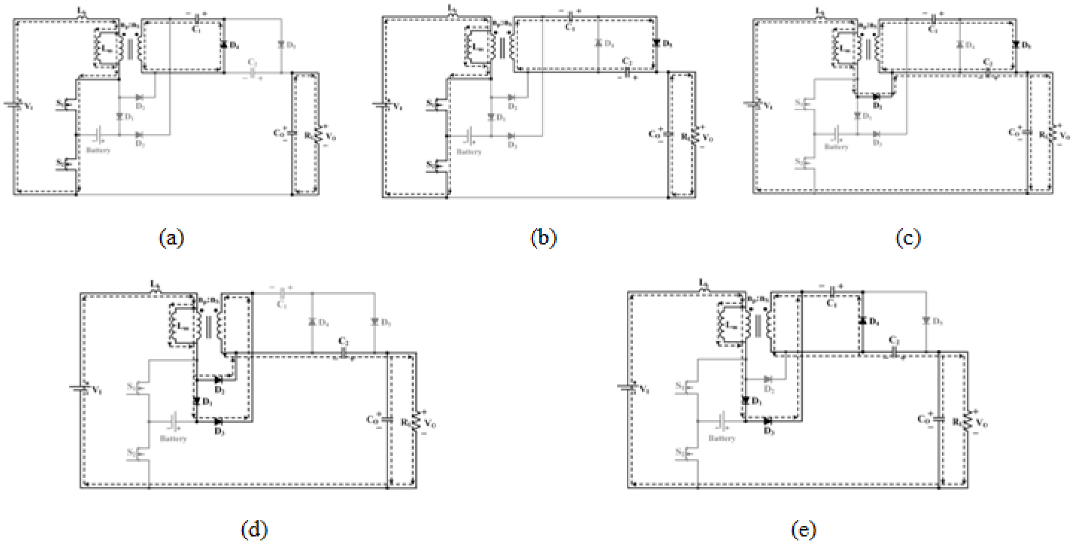


Fig. 2. Operation states of first state. (a) [t_0-t_1], (b) [t_1-t_2], (c) [t_3-t_4], (d) [t_4-t_5] and (e) [t_5-t_6]

Typical waveforms of first state are depicted in Fig.3.

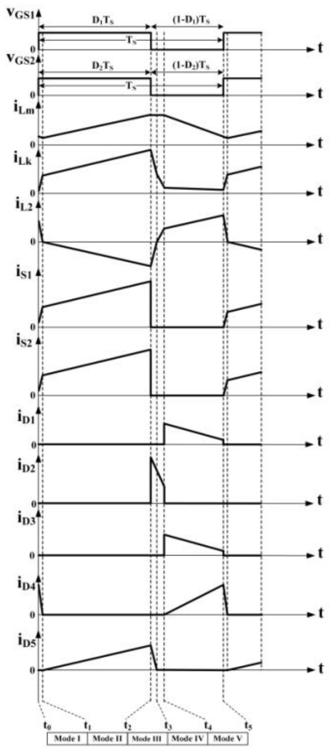


Fig. 3.*Wave forms of first state*

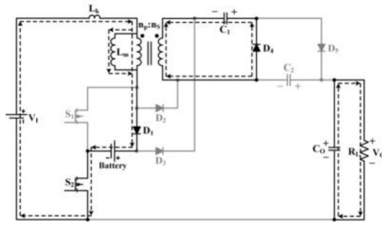
Second State (Battery charging): In this state, main power source supplies the load and charges the battery. This state consists of six operation modes (Fig. 4.).

Operation mode I [t_0-t_1]: This mode begins by turning switch S_2 on. During this mode, diodes D_1 and D_4 are on and diodes D_2, D_3 and D_5 are off. Meanwhile, input source charges the battery and output capacitor C_O charges the load. Secondary side of coupled inductor charges capacitor C_1. This mode ends when current of secondary side of coupled inductor reaches zero.

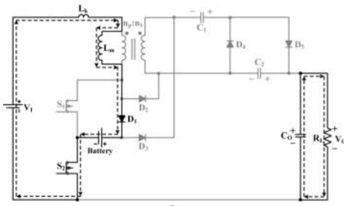
Operation mode II [t_1-t_2]: This mode begins when diode D_4 turns off with ZCS. In this mode the currents of L_k and L_m are equal and coupled inductor is charged. During this mode switch S_2 and diode D_1 are on and switch S1 and diodes D_2, D_3, D_4 and D_5 are off. This mode ends by turning S_1 on.

Operation mode III [t_2-t_3]: This mode begins at t_3 by turning switch S_1 on. Diodes D_1, D_2, D_3 and D_4 are off. Input source charges the coupled inductor and output capacitor C_O charges the load. Diode D_5 conducts and capacitors C_1 and C_2 are charged by the secondary side of coupled inductor.

Operation mode IV [t_3-t_4]: By turning switches S_1 and S_2 off, diode D_2 will be turned on. Since the currents of primary and secondary sides of coupled inductor is not equal, clamp diode D_2 conducts and the stored energy in



(a)



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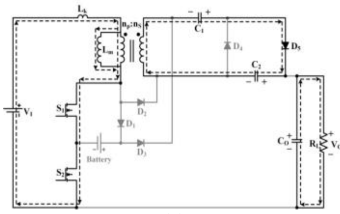

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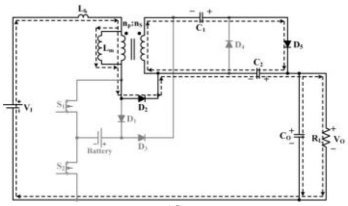

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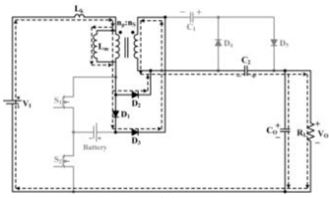

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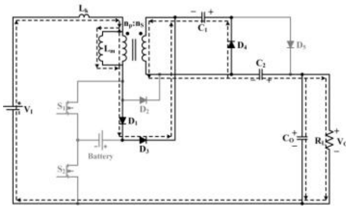

(f)

Fig. 4 Operation modes of second state. (a) [t_0-t_1], (b) [t_1-t_2], (c) [t_2-t_3], (d) [t_3-t_4], (e) [t_4-t_5] and (f) [t_5-t_6]

leakage inductor is transmitted to the output load. During this mode, diode D_5 conducts and diodes D_1, D_3 and D_4 remain off. This mode ends when the current of secondary windings reaches zero.

Operation mode V [t_4-t_5]: in this mode, switches S_1 and S_2 are off and diodes D_1, D_2 and D_3 conduct. Diodes D_4 and D_5 are off. During this mode stored energy in capacitor C2 is transmitted to the output. This mode ends when switch $S_1$is turned on.

Operation mode VI [t_5-t_6]: This mode begins when diode D_2 turns off with ZCS and continues until switches S_1 and S_2 are turned on. Diodes D_1, D_2 and D_4 are off. During this mode energy of input source, coupled inductor and capacitor C_2 is transmitted to the output load and capacitor. Operation wave forms of second state are depicted in Fig. 6.

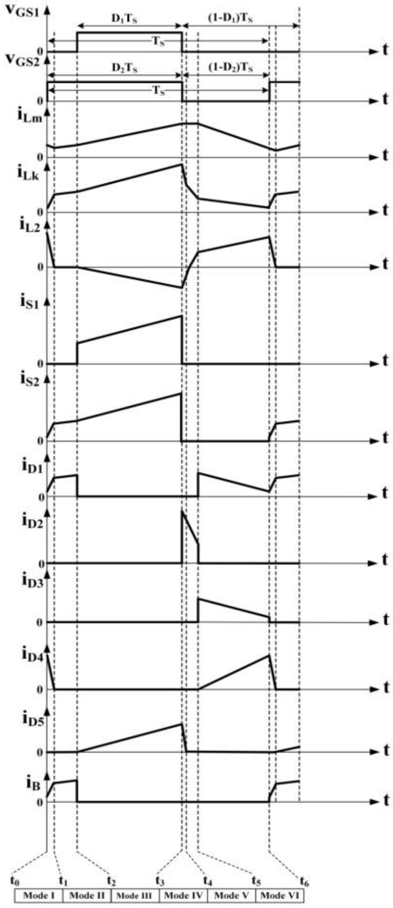

Fig. 5. Wave forms of second state

Third State (battery discharging): In this state, main power source and the battery supply the load and the battery is being discharged. This state consists of seven operation modes (Fig. 6.).

Operation mode I [t_0-t_1]: First mode begins by turning switch S_1 on. Diodes D_3 and D_4 are on and diodes D_1, D_2 and D_5 are off. During this mode, stored energy in the battery, energy of input source, coupled inductor and capacitor C_2 are transmitted to the output load and V capacitor.

Operation mode II [t_1-t_2]: Second operation mode begins when diode D4 turns off with ZCS. During this mode current of magnetizing inductor is bigger than the current of leakage inductor. During this mode switch S1 and diode D3 are on and switch S2 and diodes D1, D2, D4 and D5 are off. Meanwhile energy of input source, the battery, coupled inductor and capacitor C2 is transmitted to the output load and capacitor.

Operation mode III [t_2-t_3]: Third operation mode starts when switch S_1 and S2 are turned on. During this mode diode D4 is still on and the other diodes are off. In this mode, input power source charge the coupled inductor. And output capacitor Co charges the load. Secondary side of coupled inductor charges the capacitor C_1.

Operation mode I [t3-t4]: This mode begins when diode D_4 turns off with ZCS. During this mode, both switches are on and diodes D1, D2, D3 and D4 are off. Meanwhile, the current of leakage inductor is bigger than magnetizing inductor and the current flowing through the secondary side of the coupled inductor is negative.

Operation mode V [t_4-t_5]: By turning switches S_1 and S_2 off, diode D_2 will be turned on. Since the currents of primary and secondary sides of coupled inductor is not equal, clamp diode D_2 conducts and the stored energy in leakage inductor is transmitted to the output load. During this mode, diode D_5 conducts and diodes D_1, D_3 and D_4 remain off. This mode ends when the current of secondary windings reaches zero.

Operation mode VI [t_5-t_6]: in this mode, switches S_1 and S_2 are off and diodes D_1, D_2 and D_3 conduct. Diodes D_4 and D_5 are off. During this mode stored energy in capacitor C2 is transmitted to the output. This mode ends when switch $S_1$is turned on.

Operation mode VII [t_6-t_7]: This mode begins when diode D_2 turns off with ZCS and continues until switches S_1 and S_2 are turned on. Diodes D_1, D_2 and D_4 are off. During this mode energy of input source, coupled inductor and capacitor C_2 is transmitted to the output load and capacitor.

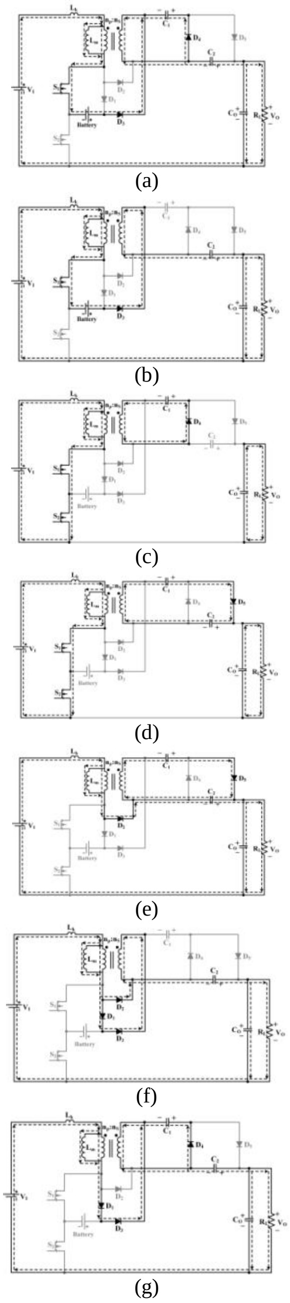

Fig. 6 Operation states twos' modes. (a) [t_0-t_1], (b) [t_1-t_2], (c) [t_2-t_3], (d) [t_3-t_4], (e) [t_4-t_5], (f) [t_5-t_6] and (g) [t_6-t_7]

Operation wave forms of third state are depicted in Fig. 7.

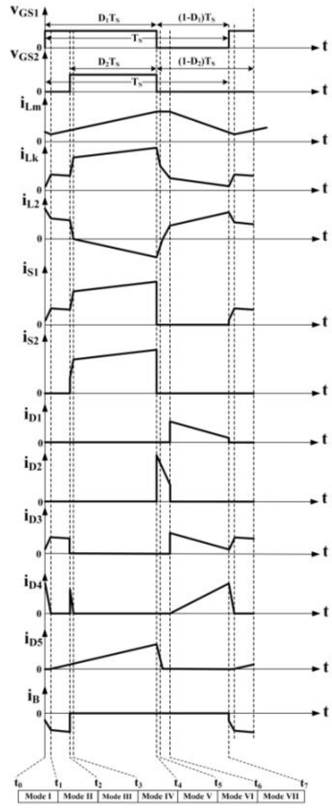

Fig. 7 Wave forms of third state

C) **Steady-state Analysis of Proposed Converter**

In order to simplify the analysis of the converter, in addition to assumptions made in pervious section, the followings are also made:

- Leakage inductance of coupled inductor L_k is ignored.
- D_{s1} and D_{s2} represent the duty ratios of switches S_1 and S_2, respectively.

A. First state (Single input)

Voltage gain of the converter in first state can be calculated as follows:

$$M_{V\ DC} = \frac{1+n+nD}{1-D} \tag{1}$$

B. Second state(Battery charging)

Using the same procedure for this state, output voltage of the converter in second state can be calculated as follows:

$$V_O = \frac{(1+n+nD_{S2})V_{in} - (2n+1)(D_{S2}-D_{S1})V_B}{1-D_{S2}} \tag{2}$$

C. Third state(Battery discharging)

Likewise, output voltage of the converter in third state can be calculated as follows:

$$V_O = \frac{(1+n+nD_{S1})V_{in} + \dfrac{(2n+1)}{n}(D_{S1}-D_{S2})V_B}{1-D_{S1}} \tag{3}$$

III. MAXIMUM POWER POINT TRACKING (MPPT) METHOD

The other main disadvantage of PV systems is that the efficiency of energy conversion is low at present. In order to enhance the overall efficiency of system and reduce the cost of energy, it is important to make the PV system work in MPP. In literature, different procedures have been addressed by researchers to achieve MPPT [7-9]. Static optimization algorithms such as Perturb and observe (P&O) algorithm [7], incremental conductance algorithm [8] and ripple correlation control (RCC) algorithm [9] have been discussed and presented in recent researches. Simple programming and implementation, and low computation have made the P&O method a practical and widely used scheme among other schemes. However, MPPT methods based on static optimization have slower convergence in comparison with dynamic MPPT controls.

IV. SIMULATION RESULTS

The proposed system is investigated in MATLAB/SIMULINK. The specifications of the circuit are given in Tables I.

TABLE I

SPECIFICATIONS OF THE PROPOSED CONVERTER

Specifications	**Values**
Input voltage (V_{in})	40 V
Battery voltage (V_B)	12 V
Output voltage (V_{out})	1st state:305 V 2nd state:290 V 3rd state:315 V
Switching frequency (f_s)	50 kHz
Coupled inductor	L_K: 1 µH, L_m: 200 µH N_S/N_P=2
Output capacitor (C_o)	220 µF
Load (R_L)	3.2 Ω

Output voltage in three different stages is depicted in Fig. 8. Input current and current flowing through the battery bank are illustrated in Fig. 9 and 10, respectively. All figures are divided into three parts. In first part, battery is not used. In second part, battery is charged and in the last part, battery is discharged. Fig. 10 shows the current flowing through the battery bank. In first part, it has zero value, in second and third parts, it has a positive and negative average, respectively.

V. CONCLUSION

In this paper, a new two-switch multi-input high step-up DC/DC converter was proposed and studied. The converter is suitable for domestic and industrial applications such as stand-alone PV systems, shipboard system, and hybrid electric vehicles. Analysis of the converter was given for three operational modes including no battery, battery charging, and battery discharging. Compared to the typical dual input DC/DC converters which use three switches, the presented converter utilizes only two switches. Hence the cost and size of the converter is significantly reduced. Moreover, simulation results validated the promising performance of the converter.

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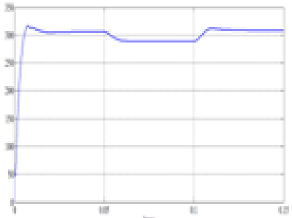
Fig. 8. Output voltage

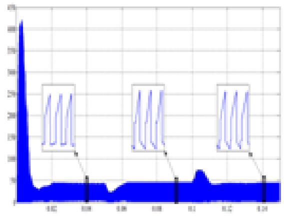
Fig. 9. Input current

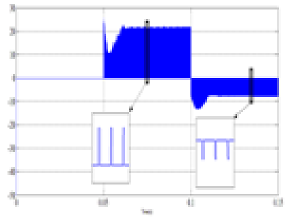
Fig. 10. Battery current

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CFD Analysis and Experimental Validation of Ethanol Diesel Blend in CI Engine

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Abstract- This paper describes the CFD analysis and experimental validation for a blend of Ethanol and Diesel in CI Engine. Ethanol is the alcohol found in alcoholic beverages but it also makes an effective motor fuel. Since, ethanol possess low Cetane number it fails to auto ignite. In order to overcome this Diesel is blended with Ethanol. Thus the Diesel will ignite and thus facilitate the Ethanol to start burning. In this work a CFD model was created and the combustion analysis was carried out and the results were validated with experimental data. The Ethanol and Diesel fuels were mixed in different proportions and they were injected to the combustion chamber of a normal diesel engine. A single cylinder PC based VCR Engine was operated with this Ethanol - Diesel blend in different concentrations and at various loads. The experiment was successful and it showed that the Ethanol could be mixed with Diesel and could be injected without any engine modification. The difference between CFD and the experimental results obtained was found within acceptable range.

Key Words: Ethanol, Diesel, CFD, Combustion

1.0.Introduction

Fossil fuels are very important to us today. The increase on energy demand and increasing petroleum price in the worldwide has increased the study of alternative fuels for internal combustion engines. Biodiesel and DEB (Diesel – Ethanol Blend) have received much attention among these alternative fuels for Compression Ignition (CI) diesel engines. Ethanol is one of a renewable fuel because we get it from raw materials such as corn, sugar cane, sugar beets, molasses, cassava, waste biomass materials, sorghum, barley, maize, etc. Ethanol can reduce the consumption of conventional gasoline and it has been successfully used to blend with gasoline fuel as part of its alternative. However, due to the difference in chemical and physical properties, it has not been commercially used yet. At present, significant investigations of the potential application of DEB on diesel engine have been carried out.

Hansen et al. [1] found that the engine power decreases by about of 7 to 10 % and the brake thermal efficiency increases by about of 2-3% at rated speed when investigated the Cummins engine performance with 15 % ED fuel In the same model engine with two and backgrounds.

blends. In the same model engine with two blends containing 10 % and 15 % ethanol, Kass et al. [2] tested the torque output and got an approximate 8 % engine power reduction for both fuel blends. Huang et al. [3] experimented by 10%, 20%, 25% and 30% ethanol-blended diesel fuels and examined the engine performance and exhaust emissions of diesel engine. It results; increasing amount of ethanol in the blended fuels decreased the brake thermal efficiencies. Also Rakopoulos et al. [4] studied the effects of ethanol blends with diesel fuel, with 5% and 10% (v/v) on the performance and emissions of a turbocharged direct injection diesel engine. It results the increasing the amount of ethanol in the fuel blend decreased the brake thermal efficiency and increased the specific fuel consumption. Diesel fuel blended with ethanol up to 10 vol. % results [5–7] to increase the engine efficiency, improve fuel economy and reduce its harmful emissions. Also yield a significant reduction of carbon monoxide and nitrogen oxide [8] and particulate matter emissions [9, 10].

The major drawback of ethanol in diesel engines is less solubility of ethanol in diesel fuel and it leads the phase separation and water tolerance in ethanol–diesel blend fuel. The phase separation can be prevented by adding an emulsifier or co- solvent. Here by adding an emulsifier that acts to suspend small droplets of ethanol within the diesel fuel and it usually requires heating and blending steps to generate the final blend. introduce a more challenging dataset containing over 1800 annotated human images with a large range of pose variations and backgrounds.

tolerance in ethanol–diesel blends. The phase separation can be prevented by adding an emulsifier or co-solvent. Here by adding an emulsifier that acts to suspend small droplets of ethanol within the diesel fuel and it usually requires heating and blending steps to generate the final blend. The properties of Diesel and Ethanol are shown in Table 1. In this study we are using DEB15 (15% Ethanol and 85% Diesel)

Property	Diesel	Ethanol
Chemical formulae	$C_{12.35}H_{21.76}$	C_2H_5OH
Composition in %		
C	87.13	52.14
H	12.88	13.13
O	0	34.73
Density	820	786
Viscosity, Pa s	2.8	1.20
Latent heat, kJ/kg	375	840
Cetane number	48	6
Lower heating value, MJ/kg	42.90	27.47

Table 1: Fuel Properties

2.0 CFD Modelling

The combustion chamber is modelled and the analysis is carried out in detail using a CFD tool package ANSYS FLUENT. A three dimensional periodic, in-cylinder, transient system for a direct injection diesel engine is modelled by solving a set of governing equations from the conservation of mass, momentum, energy and species theories. The Figure 1 shows the meshed geometry of the cylinder.

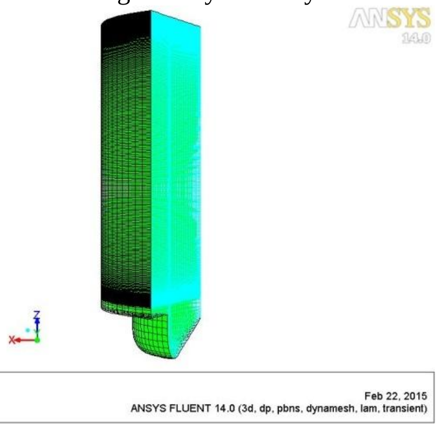

Figure 1: Meshed Cylinder Geometry

The in-cylinder parameters are

Connecting rod length: 140 mm
Bore: 80 mm
Crank radius: 55 mm
Crank shaft speed: 1500 rpm

In this present study the turbulent model selected is standard k- ε. This model of turbulence are of two-equation model in which the solution of two separate transport equations allows the turbulent velocity and length scales to be independently determined. It is a semi-empirical model, and the derivation of the model equations relies on phenomenological considerations and empiricism. The turbulent (or eddy) viscosity, μ_t, is computed by combining k and ε as follows:

$$\mu_t = \rho \, c_\mu \frac{k^2}{\varepsilon}$$

The combustion model used is species transport with volumetric reactions. The inlet diffusion and diffusion energy source is turned on. Eddy dissipation is used for turbulent chemistry interaction. This approach is based on the solution of transport equations for species mass fractions, with the chemical reaction mechanism defined by user. DPM fuel injection model is also used in this study.

3.0 Experimental Setup

The engine setup shown in Figure 1 used for experimental investigation is a single cylinder, Four Stroke, Water cooled, PC based VCR Engine. It is connected to a eddy current type dynamometer for loading.

The compression ratio can be changed without stopping the engine. The setup is provided with necessary instrument for combustion pressure and crank angle measurement. These signals are interfaced to computer through engine indicator for Pθ-PV diagrams. Provision is also made for interfacing air flow, fuel flow, temperature and torque measurement. The setup has stand-alone panel box consisting of air box, two fuel tanks for dual fuel test, fuel and air measuring unit

Figure 2: Experimental Setup

4.0 Result and Discussion

This work is carried out in two stages the numerical CFD analysis and the experimental validation. Each parameters are studied both numerically and experimentally with DEB15.

4.1 Combustion Peak Pressure

The peak pressure obtained by CFD analysis is 61 bar and experimentally the peak pressure is 58 bar. This change in 3bar is almost negligible. The figure 3 shows the CFD result and figure 4 shows the experimental result in VCR Engine.

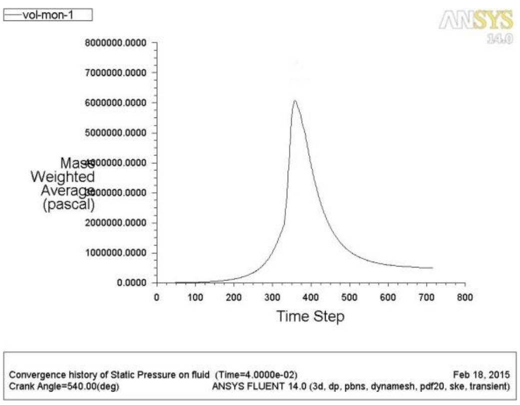

Figure 3: P-θ CFD Result

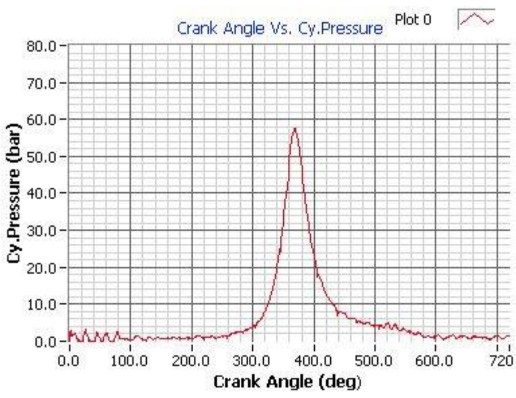

Figure 4: P-θ Experimental Result

4.2 Performance Characteristics

The performance characteristics of a single cylinder four stroke engine with DEB15 as fuel are discussed below.

The figure 5 shows the variation of volumetric, brake thermal, indicated thermal and mechanical efficiencies with brake power. The volumetric efficiency remains almost constant. The mechanical efficiency is increasing with the increase in break power. The brake thermal efficiency is also increasing, but at higher load there is a slight decrease can be noted. The indicated thermal efficiency shows an irregular variation with increasing load. All these performance characteristics with DBE15 as fuel lies closer to that of diesel alone operation.

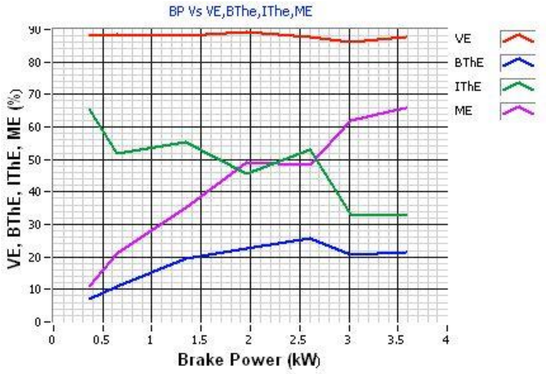

Figure 5: Efficiencies vs Brake Power

4.3 Exhaust Gas Analysis

The exhaust gas analysis is done with ANSYS FLUENT. The figure 6 shows the NO_x emission. The mass fraction on NO_x is $4.03e^{-05}$.

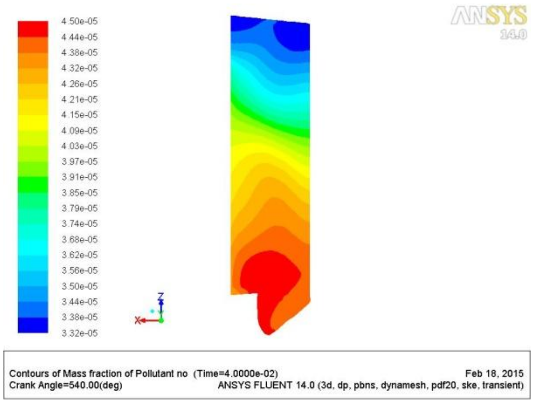

Figure 6: NO_x Emission

We can see the variation in the concentration of NO_x from he above diagram. The concentration is more athe the piston head and goes on decreasing upto the cylinder head.The mass fraction of soot is $6.43e^{-05}$ and CO emission is 0.129. The figure 7 & 8 shows the soot and CO concentration inside the chamber.

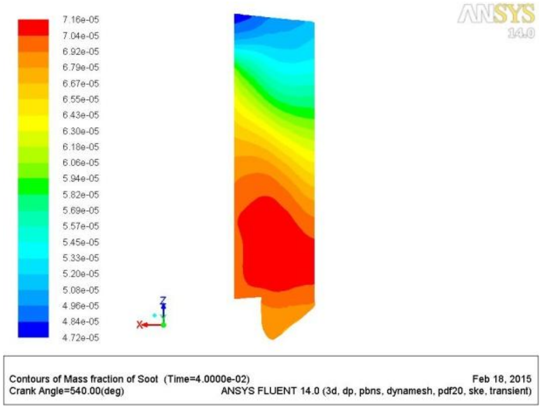

Figure 7: Soot Concentration

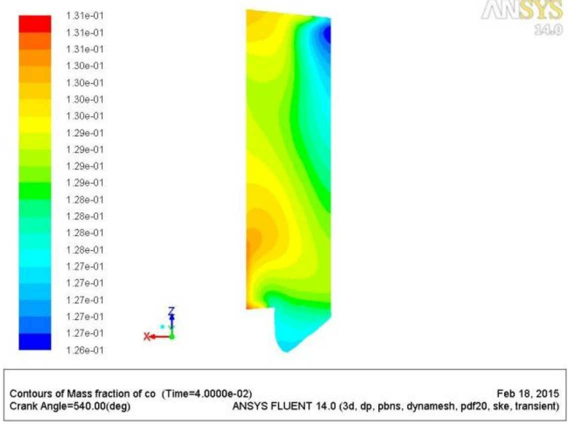

Figure 8: CO Emission

The mass fraction of unburnt oxygen is noted as $2.52e^{-13}$. This shows that almost complete combustion is taking place and the injected fuel is fully utilized by the air inside the combustion chamber.

5.0 Conclusion

The numerical CFD analysis using ANSYS FLUENT and the experimental study with DBE15 is done. The results are comparable which are obtained both numerically and experimentally. The peak pressure obtained shows only a change in 3 bar pressure. And it is also seen that the ethanol diesel blend can be used in normal CI engine without any engine modification. Thus the CFD tool ANSYS FLUENT is very reliable to predict the combustion and emission characteristics.

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The Restoration of Shadorvan Dam-Bridge, Cultural & Historical Landmark of Shooshtar

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Abstract- The cultural-historical landmark of Shooshtar has traversed a very long distant since the ancient era. In fact it was the mutual corporation of history and nature that end up as a city like Shooshtar which is a combination of both tradition and culture, emerged authentically in a wild natural way through time; and taking the important historical landmarks under consideration, it is expected to become one significant tourism attraction district. Retaining the sustainable aspects of the city, this research aims to restore connection between natural and historical layers within the boundaries of natural city landscape restoration and its main purpose is to provide a range of principles and solutions for a sustainable development, natural resources' conservation, and retaining the historical sight of Shadorvan Bridge.
Primary in this research, the issue and research method will be defined and afterwards, paraphrasing the keywords of historical landmark and the principles of landmark restoration would lead toward a series of principles for sustainable conservation in a historical landscape. Studying the site would be the next step and following the landscape restoration rules, some issues such as points of strength & weakness, opportunities, natural threats and vernacular culture will be concluded in a table, which all finally will indicate the criterions of preservation to the historical landscape restoration of Shadorvan Bridge. The total conclusion would reveal that the restoration of all the existing layers through the land and understanding the interconnections will guide us to a comprehensive & general restoration ways of the similar landmarks. The fulfillment of this research is achieved by means of descriptive-analytic method (with practical approach) in the context of library studies, harvest field and documents review, detailed plans, summary information and applied access to general principles.
Keywords: Tourism, Shadorvan Bridge, Shooshtar, region, cultural landmark

Introduction

Every inch of this country has natural arena with historical, artful and cultural landmarks of Persian civilization -the sites which have been constantly neglected; Meanwhile any plan for restoration would lack a 'comprehensive approach' toward their natural and historical values (Afshar Sistani, 1371: 574).

In a natural comtext, history is seen as ancient landmarks. "This dialogue between natural appearance and cultural one, shall bring up a dynamic and prevalent process of change and evolution which guarantee the sustainability and survival of a civilization. The prosperity of structural relation between nature and culture - which have been achieved through time- and the maintenance of the proofs to the contemporary age, lead to figure historical symbols with environmental values." (Behbahani- Inanlou, 1379). Usually the failure in removal of landscape obstacles and difficulties is not only related to the design disabilities, but also is directly related to the insufficiency of data to offer a precise definition for site threats and strength and weakness points (Mothloch, 2001: 286).

One of the most important discussions of current days within urban design management and environmental design, is restoration of historical context management, which is declined for the weak points in authority functioning strategies in historical landscape of Shadorvan. Hence, this issue is dedicated to recognition of Shadorvan Bridge region –newly enlisted in UNESCO world heritage- as a historical-cultural site to be the primary concern for its restoration process.

Subject and research necessity

Historical squares or sites are to define credit and originality for a city and have artistic, cultural and historical importance. These sites -containing the elegant and vernacular architecture of the region- “help to develop historical knowledge or exist as a historical document” (Vinas, 1389: 43). Although urban historical sites play a very important role in the architecture and originality of the city, but occasionally turn into an element without any sign of fortime, due to paradoxical and inefficient ideas and theories. Here is a quotation from the Italian critic and thinker, Cesare Brandi (1967):

“There is nothing intuitive and free-standing exterior as a ‘historical structure’. What we call ‘historical structure’ is a concept defined in the relative connection of contemporary human with the structure built in the past and gains significance accordingly. In another words, historical work is a phenomenon resulting as the way human looks upon a work, which for the independent qualities lied in its essence and nature and also for all it gained through long times, could be the subject of thoughtful discussions.” Therefor Shadorvan is considered as a cultural landscape because “it compromises the unique features of the land and is a compound indication of natural and humanistic works.” (UNESCO, 2009).

Shooshtar -3,538 Sqm- in located at the center of Khouzestan province. Having almost 100 aquatic structures, Shooshtar is one of the most rare cities with old works of aquatic engineering and hydrology. Studies in this region show disconnection and chaos among regional historical and natural continuity, therefor specific conservation plans are considered to be mandatory.

Research Method

The research method of this issue is descriptive-analytic method (with practical approach) in the context of library studies, harvest field and documents review. In order to achieve a better cognition of the historical-cultural landscape and their definitive and practical aspects, in the current research we have tried to study the cultural landscape and the impressive factors upon its existence, and in order to provide and interpret the case studies, we chose the harvest field method.

The ecology of historical landscape restoration

What matters the most in restoring the landscape, is humanistic view along with the restoration of design nature. In fact here we spot two different viewpoints toward the concept of restoration: One is by ecologists who believe that “the scattered pieces of nature must be positioned back where they used to be”, and the second is the viewpoint of landscape designers who mainly say that “the modification of a demolished landscape lies in creating a place where could be reused by people.”

Here we have to mention that all the layers of existing values of the landscape -whether cultural or natural- must be taken under consideration and being restored [UNESCO-ICOMOS, 2009: 8]. The most recent viewpoints on landscape restoration suggest that the mere ecological study of natural environment and restoring the nature within the landscape do not suffice. This approach, defined within the measures of landscape design, on one hand aims to restoring the ecological bed of the region and on the other hand, -considering the cultural and historical features of the region- also tries to restore the signs, symbols and artistic, cultural and historical monuments (Figure 1).

“In fact by offering a humanistic design, the landscape restoration is looking for a way to ascend the quality of landscape.” (Pour-Yousefzadeh, 1391: 6). And finally we should mention that restoring the landscape compromises a wide range of ecological, social and cultural notions, and brings up solutions in order to restore them on the basis of sustainable development purposes. Table 1 indicates the effects of natural landscape for ecological study.

Figure 1: Shadorvan dom-bridge, Shooshtar, 2005. Source: Ali-Mohamad Chaharmahali’s private atchive.

Table 1: SWOT natural landscape of Shadorvan. Source: the authors.

context	In the site		Out of the site	
	Strong points	restrictions	opportunities	threats
ecology	The Karooun river with non-stop stream in the site. The strong stone-bed of the river. High ecological power by sustainable and unsustainable resources.	Free and isolated edged near the site & river. Inappropriate functions near natural spaces. River as a trash bin.	Linkage between the existing natural resources, and historical & modern context of the city within the general design. Development of green civic spaces & making a green corridor at the perimeter of Shadorvan dom-bridge.	Falling quality of natural visual effect of site for indigested interferences. Oscillation of the river water surface for the irrigation plans and dam constructions.

Landscape restoration

"Landscape restoration is an economical concern, and is a valuable challenge among all the new solutions for the environmental management." (France, 2008. Preface). As a national heritage in an industrial world, cultural and historical landscapes are bringing up changes in economy, environment and social opportunities in the way that "the purpose of restoration has to be as consolidation of potential unity of the artifact." (Brandi, 1388: 41). Neglecting and inappropriate development of urban landscape, and also the ever-increasing human interferences has had a strong impression on cultural heritage and landscape of ecological society and mostly, the inappropriate decisions will threat the survival and continuity of these cultural heritages (Table 2).

Table2: restoration of historical landmarks according to the theories of restoration
Source: www.dio.gov/Secretary . (of the interior standards)

preservation	The process consists primary measuring to preserve and restore the current materials and situation which helps to avoid replacement of new materials and structural methods.
rehabilitation	To prepare a situation for using the historical site, or to restore, change and add. Albeit these should not exceed the historical and antiquity features of the region.
restoration	The act or process of describing the form, features and identity of a place, according to the related historical period. The precess consists of eliminating the later-added extensions/elements and restoring its lost features through time and events.
reconstruction	The act or process of new construction of forms and landscape elements and structure, aiming to create the closest similarity with a specific historical period and placement it used to be in.

The principles of Natural landscape restoration:

1. To follow the sustainable development measures, extensively and within the whole landscape, without mere emphasis on conservation regions. (Bell. 2007:410)
2. To restore & reconstruct the ecological values by methods of natural revival and reconstruction, modifying operations, "constant and long term management of natural landscape & design in order to revive the health of landscape and humanistic advantages." (Motloch,2001: 211) (figure 2).
3. "Landscape design in order to achieve the best aesthetic experience" (Craul et al, 2008: 22) and to design as the natural patterns. (Bell. ،2007:297).

Figure2: Restoration of Shadorvan dom-bridge, 2013. Source: Fereshteh Taleb-Mashhadi.

The natural-historical landscape of Shadorvan

Cultural-historical structures and monuments try to preserve the survival and values while keeping up with the contemporary needs (by fixating the historical function or giving it the proper usable function). UNESCO world heritage committee had offered a definition for the cultural landscape as the geographical distinction mark of the lands: “A show combined of natural and humanistic monuments.” (Fowler, 2003: 15). In architecture and urbanism, the historical landscape seems to be a brand new topic which has been listed in the world heritage category for the contract signed in the UNESCO, and attracted the attention of countries. The cultural landscape is a emanation field of nature and culture through time, supporting cultural and emotional functions as well as physical ones while often has an appreciative cultural and positional identity. Certainly by the improvement of technology and population & according to the diversity in human behavior patterns through time, the human behavior -in any historical and cultural site- has been different. (Mokhles.2013:4).

Shadorvan is a cultural-historical tale of the region, hence preserving it depends on protecting the natural , cultural and physical features of the region, simultaneously. Protecting these sites and analyzing the efforts that have been done or are to be done, shall enhance the life quality and transmit the sense of place and identity much better to the next generations. Shadorvan is a combined model for culture and nature of a society & its development will cause a considerable increase in cultural exchanges.

The necessity of privacy for historical monuments

“The old landscapes will not reemerge, but the ways to preserve and make sustainability of them along with melting into modern life and taking advantage of their urban/landscape design principles are the issues that have to be taken under consideration.” (Antrop, 2003).

The mere preserve and restoration is not the things that matter, however maybe sometimes only the restoration will end up more sustainable and functional. The restoration must obey the proper function of the historical monument which shall avoid its isolation and oblivion.

“The restoration, as we know today, does not date very back in time, although some cautious actions can be tracked. But any restoration in order to keep the ancient monument is a modern act of the recent centuries. Keeping the ancient models is an action that has several reasons & shall contain many values for human societies.” (Motaghi. ،2009:48).

In a world that undergoes quick changes, time and money used for restoring the ancient monuments because of their inner value, keeping historical beauty & landscape, visual & tangible documentation, and also for artistic & cultural sustainability. The aquatic system of Shooshtar is settled in a natural land, hence its restoration must follow the natural situation of the region & the historical-natural relations to the surrounding elements. Therefor establishing privacies seem mandatory –especially large scale civic programs such as building dikes. These information must be verified by the organization during the Feasibility study process.

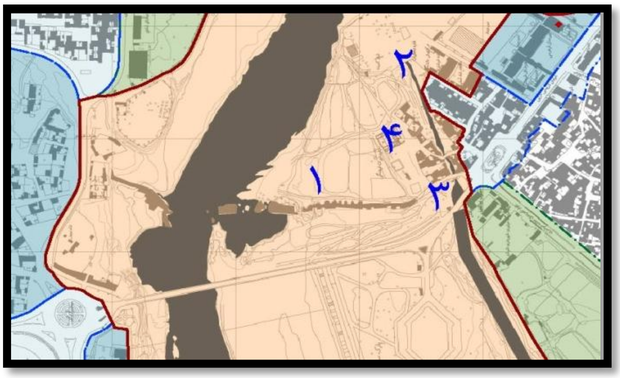

Figure 3: Shadorvan sanctum and arena. 1- Shadorvan dom-bridge. Source: Shooshtar detail design, 2005.

Merits for Shadorvan historical landscape restoration

Proposals to achieve merits for preservation and restoration of Shadorvan historical landscape:

1. To record Shadorvan as a "cultural-historical landscape": this can bring global credit for this region. This shall assign a wider domain than the current UNESCO list. It will also lead to elimination of industries and low-value buildings.

2. preservation plans: Studying archeology, we can use "preservation, restoration & reconstruction" (Feilden at et 1998.82) plans to preserve and revive Shadorvan historical landscape.

Table 3: SWOT of preservation of Shadorvan cultural landscape. Source: the authors.

	In the site		Out of the site	
preservation	Strong points	restrictions	opportunities	threats
	1. To assign the preservation limits by the cultural heritage organization & to make a technical preservation committee. 2. To keep the main interface in the city context despite the damages through time. 3. To restore the historical landscape.	1. Management weak points in scientific restoration methods & hasty operations with inappropriate techniques. 2. general ignorance about the existing values due to weak informing system. 4. Inadequate supervision and operational controls for different parts of the historical landscape in order to prevent any interfering. 5. inadequate budget for restoration & reconstruction.	1. Providing jobs and income for the citizens. 2. improve the experimental and technical knowledge of the workmen and managers, in the case of settling a systematic instructional management for restoration projects.	1. reluctancy of the residents to restoration and renovation of the units adjacent to the old context. 2. Weakness in public financial resources for city development & its effects on preservation project resources. 3. decrease in city income rate because of restriction in building projects around the preserved sites. 4. The possibility of an increase in water level which may lead to flood and demolition of constructions.

Necessity of reconstructing the Shadorvan dom-bridge

The project is base dupon the idea of preservative restoration, and the purpose is to bring back the originality and credit of the monument, without any change in its origin. This could be fulfilled by:

1. resolving the damages, frazzles, weathering, electrical cables, humanistic interferes and etc.
2. preventing any more damage and fortifying the structure.
3. providing a good sight and viewpoint for Shadorvan dom-bridge.

4. Providing a safe place in the city and removing abnormal behaviours close to the bridge.
5. Protecting the structure as a valuable heritage and preserving it for the following generations.
6. Preparing an organizing program: Unfortunately some plans and ideas have been performed without dedicated studies, on the bridge and surrounding area that has destroyed the natural and historical sight. (figure 4)

To take back originality to the monument will make it as a dynamic element; also to insert dynamism to the surrounding area will accelerate this achievement.

When we reach this purpose, we would be able to show off the power and intelligence of our ancestors and the potentials of our vernacular structures. It will be a way to develop tourism and attract in-border and foreign tourists. (Table 4).

Figure 4: Non-normative restoration of Shadorvan dom-bridge, 2013. Source: Fereshteh Tleb-Mashhadi.

Table 4: SWOT analysis table about historical landscape of shadorvan. Source: the authors.

context	In the system		Out of the system	
	facilities	restrictions	opportunities	threats
Function of the site	1. The assigned privacy for Shadorvan Dom-Bridge 2. Natural lndscape along the river 3. Possibility of creating a recreational function for the public use of citizens. 4. Possibility to release the east side of the site and refunctioning it for preservation and green land development & tourism service.	1. lack of transparency & unity n the construction merits -offered by the responsible organizations, around the ancient district. 2. Erosion of the old adjacent residential context. 3. Insufficient quality & quantity of the urban istallations and equipments around the site. 4. lack of services and tourism facilities. 5. The existance of irrelevant structures around the historical context.	1. To perform the master plan of the city by the approach of taking advantage of rich resources of the urban historical and natural context. 2. Creating more job opportunities by constructing tourist guest centers. 3. Organizing the other site-related urban centers by organizing the site landscape.	1. To cause disturbance for the natural & humanistic landscape by performing new constructions around. 2. To create duality between the the restored and developed context around the historical site with the old residential and non-residential ones throughout the city, in the case of not having a site plan. 3. To increase pressure to the river and water pollution.

Merits for natural-historical landscape of Shadorvan preservation

Within the historical context of Shadorvan that indicates wide range of human-nature interrelation, merits are assigned as follow:

Historical monuments for nations are documents of ancient glory –a witness on a great old civilization remained up to the present time. These visible proofs could enhance to form a national-cultural identity and help the human to remember memories in the place. They could bound the society of today with the past and hence, form a special meaning to the present days. Having gained much recognition and significance since 1960s to justify the historical landscape preservation, this attitude is in a direct relation with the contemporary sensitivities, sociological index, and concept of individuality and builds a barrier against cultural synchronizations. “The recommendation on beauty and landscape features’ preservation 1962”, edited in the 1960s says: “Historical districts are heritages & their destructions will cause loss of serenity & also considered as an abuse to social rights, even if it doesn’t cause economical loss.” Contemporary human is more aware about the importance of human values’ unity and know the ancient monuments as a heritage for all, accordingly their preservation is a general operation which in the most original way consists of every individual’s corporation. The most defensive reasons for different valuable aspects of historical monuments usually consist of aesthetic, social and cultural values, rather that tangible economical & commercial ones. Although in today’s living style, to preserve and take use of structures and historical landscapes faces many challenges and economic crisis. We must keep in mind that in the economically competitive world of today, the historical monuments are seen as ‘produsts’ which are rare, therefore, worthy. This feature of being rare and uncommon could raise financial benefits as for tourism attraction or special social-cultural events. The results of studying the solutions for the historical landscape preservation merits are documented in table 5.

Table 5: Methods of conservation and restoration of Shadorvan cultural landscape. Source: the authors.

solutions for the natural landscape of Shadorvan bridge preservation
1. To remove polluted water, “to prevent pollution in the focal point” (Botkin 2008:418) and to prevent sewage penetration into the river of Gargar. 2. Restoration of site & removing the desolated or architecturally worthless structures. (Craul et al,2008: 22). 3. To preserve and restore earth and prevent soil drifting & erosion. Also to revive vernacular vegetation. 4. To prevent constructions which are heterogeneous with the site.
solutions for the historical landscape of Shadorvan bridge preservation
1. To fortify the dignity of cultural heritage organization among civil decision-making institutions & to define a fair budget for this organization for performing requested plans. 2. To fulfill fundamental & comprehensive studies on the natural-historical site for learning more about the roots & processes of the complex configuration & also in order to gain dominancy on sustainability aspects of it. 3. To provide and fulfill a purging plan of site and surrounding area, plus restorations according to the sustainable preservation and development measures. 4. Ratification and performing comprehensive rules for urbanism and restoration according to urban development plans, needs of the citizens, and coherent reservation of historical monuments between civic institutions and Cultural Heritage Organization. 5. To encourage the owners of old rusty buildings for restoration and renovation according to the declared measures, through encouraging policy. 6. To develop transportation and communication systems in & out of the city & to construct proper roads and bridges.

Conclusion

As a historical landscape, the Shadorvan dom-bridge area stands as a linkage between now and past; a medium to helps human gain an acceptable fair cognition about his past and identity. So in the first place, people would know the landscape and its identical-cultural values, and second, tries to preserve and transmit it to the next generation. The harmony between a structure and its surrounding which is gained through decades and centuries has a very high importance and as a basic principle should not ever be demolished. Also it is not justified to demolish the area or make a transmission to build a single structure, just in case of instant considerations.

To study the landscape of Shadorvan, its special identities and their interrelations, is an important obligatory of present time. As a main stream of recreation and historical linkage between nature and urban setting, Shadorvan dom-bridge had potentials which enroot in the pass of time. Although this cultural-historical complex has been existed since very long time ago but up to now, its unique identity has never been the basis of its special organization, hence, it is mandatory to study, know and preserve the identical, historical, cultural and natural features of the monument for the sustainability of the landscape identity. Shadorvan (along with other historical contexts of Shooshtar), through a historical relation between human and nature, offers a great potential for sustainable development programs and define new standards for enhancement of living styles according to the historical, cultural & tourism capacities. By precise and deep studies on the structural features of this complex we shall create a harmonious corporation between human and nature.

Feuilleton

1- Preservation
2- Rehabilitation
3- Restoration
4- Reconstruction

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Sliding mode control of Vienna rectifier with output voltage control

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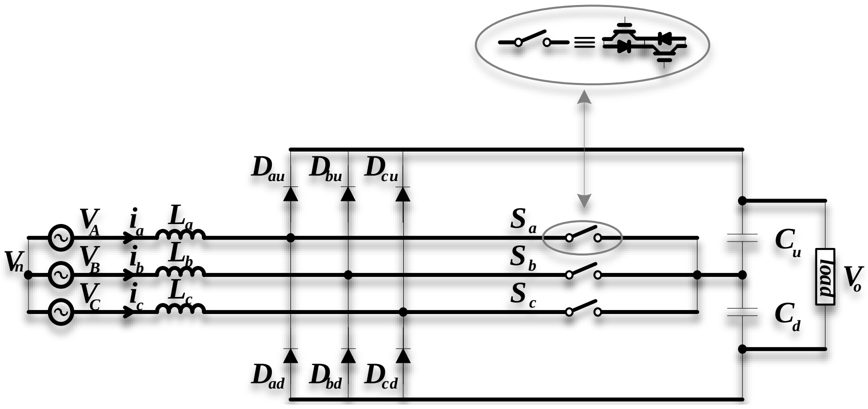
Abstract: In this paper, a Vienna type boost rectifier is discussed and controlled using sliding mode control. Sliding mode control function is defined to control output. The object of this system is to provide desired output DC voltage in any possible circumstances.

Introduction:

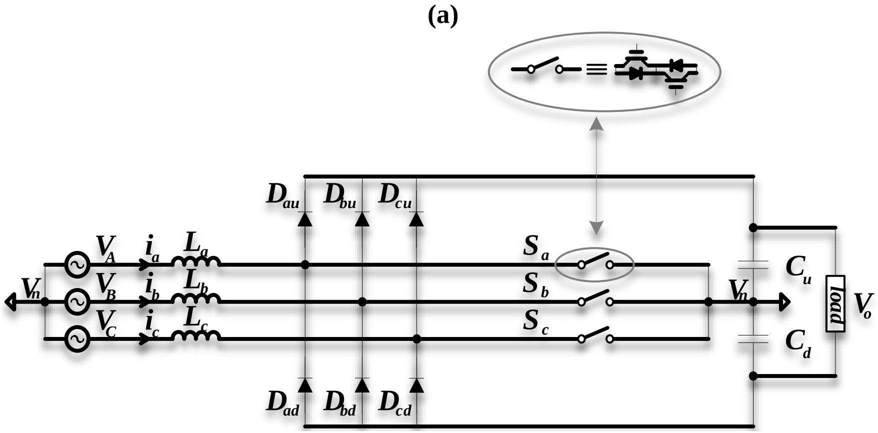
Three-phase AC-DC power supplies (rectifiers) are widely used in many aspects of power systems, such as: 1) High-voltage direct current (HVDC) systems; 2) Uninterruptible power supply (UPS); 3) Variable speed drives; 4) As generator side converter for permanent-magnet synchronous generator (PMSG) [1]. Conventional rectifiers are known using diodes and thyristors to supply uncontrollable and controllable dc power. Current harmonics are the most important problem of these converters, which causes lower power quality, and voltage distortion. Another problem is the low power factor at input side of rectifiers. Several standards are issued to prevent or decrease the mentioned problem such as IEEE-519, IEC555. In order to overcome the problems some options were used, such as passive filters, active filters and hybrid filters. However, these options increase the cost and losses of system which are good reasons to reduce efficiency of the converter [2]. Because of these problems, AC-DC converters can be improved, using power switches and changing in the circuit diagram [3-8], [2].Various AC-DC converters in terms of control system and circuit structure have been introduced up to now [2], [9-11]. In [2] AC-DC converters are divided into five major groups Buck, Boost, Buck-Boost, Multilevel and Multi-pulse. Each one of these converters can operate in unidirectional and bidirectional and in particular goals with particular benefits. In [9] rectifiers are divided into two major groups; controlled and uncontrolled rectifiers that each one of them is divided into isolated and non-isolated and at last each group appear in bridge and full-wave. Power factor correction (PFC) of conventional rectifiers and passive diode rectifiers and performance of the three phase buck type rectifier with PFC are studied in [10-11]. In addition, the essence of four active three-phase PFC rectifiers (active six-switch boost-type PFC rectifier, the VIENNA rectifier, the active six-switch buck-type PFC rectifier, and the SWISS Rectifier) are dedicated. Each one of these rectifiers has positive and negative points in various applications. For example, the diode rectifiers with a boost converter could regulate the output voltage and also improve the input power factor. If the input three-phase voltages are unbalance, correcting the power factor may be one of problems. If the load is sensitive to voltage changes, so the adjustment and balancing of rectifier's output voltage with poor control capability will problematic under distortion and harmonic condition of utility side. Three-phase Vienna rectifier [7] with six diodes and three bidirectional power switches is one of acceptable structures in PFC and boosting voltage, which is widely discussed in recently published papers with promoting control policies [1], [12-17].One of the most important benefit of Vienna rectifier is its capability to work under various distortions in input side such as harmonic distortion and unbalance input voltages [18-19]. The introduced structures in [18-19] are three-phase three wires which need to complicated control system under unbalance input voltage conditions. In [20] to avoid from mentioned complication the Vienna rectifier for three-phase four wires system is proposed. The benefit of fourth wire appears in unbalance and distorted input voltage to lead distortions into neutral point. Many control methods have been introduced to control Vienna rectifier [4], [9] and [21]. These techniques are effective to control Vienna rectifier in PFC and output voltage regulating. But it should be noted that under distorted input voltage conditions control of the system is complicated. Sliding mode control (SMC) is one the methods, which widely have been used in power electronic converters [22-28]. SM is an effective control method with high frequency performance for nonlinear systems. It has some advantages such as simple implementation, disturbance rejection, strong robustness, and fast responses, but the controlled state may exhibit undesired chattering [29]. In this paper, sliding mode is used to control the three-phase four wires Vienna rectifier under normal and distorted conditions of input voltage. Each phase of three-phase input is controlled individually in order to make control easier and clear. In order to prevent chattering phenomena the fixed frequency SMC is utilized.

System configuration

Three-phase three wires and four wires Vienna rectifiers are illustrated in Fig. 1(a) and Fig. 1(b) respectively. In this paper three-phase four wires Vienna rectifier is considered. In the normal condition V_A, V_B and V_C are input three-phase voltage and each phase has 120° phase shift in comparison to other phases. L_a, L_b and L_c are input filter inductors. S_a, S_b and S_c are bidirectional power switches, insulated-gate bipolar transistor (IGBT) with common emitter connection for each double switches.



(a)



(b)

Fig. 1
a. Three-phase Vienna rectifier
b. Three-phase Vienna rectifier with connected fourth wire

Based on the presented structure in Fig. 1(b) the three phase system can be considered as 3 single phase system without loss of generality and exclusive feature of rectifier. Fig. 2 show single-phase structure of Vienna rectifier. Compensation scheme and control procedure will be executed on single-phase structure then it will be generalized to three-phase system.

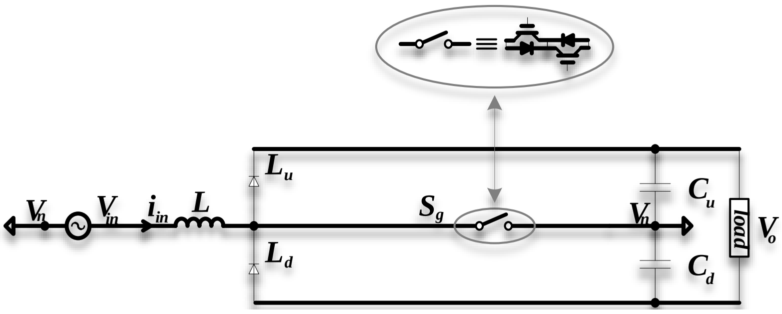


Fig. 2 Single-phase Vienna rectifier

Converter performance

Vienna rectifier perform as boost AC-DC converter. In order to describe performance of the Vienna rectifier, single-phase structure of AC-DC converter is considered as Fig. 2. Performance of the Vienna rectifier is divided into two states which are shoot through and non-shoot through.

Shoot through

In this state without noticing to input voltage phase, power switch $S_g$is turned on and AC current flows through inductor L, power switch S_g and input voltage source. Fig. 3(a) shows shoot through state of Vienna rectifier, which bidirectional power switch is turned on and diodes L_u and L_d are reverse biased.

Non-shoot through

In this state power switch$S_g$is turned off and diodes L_u and $L_d$are forward biased due to inductor current. Fig. 3(b) shows currents path in the non-shoot through.

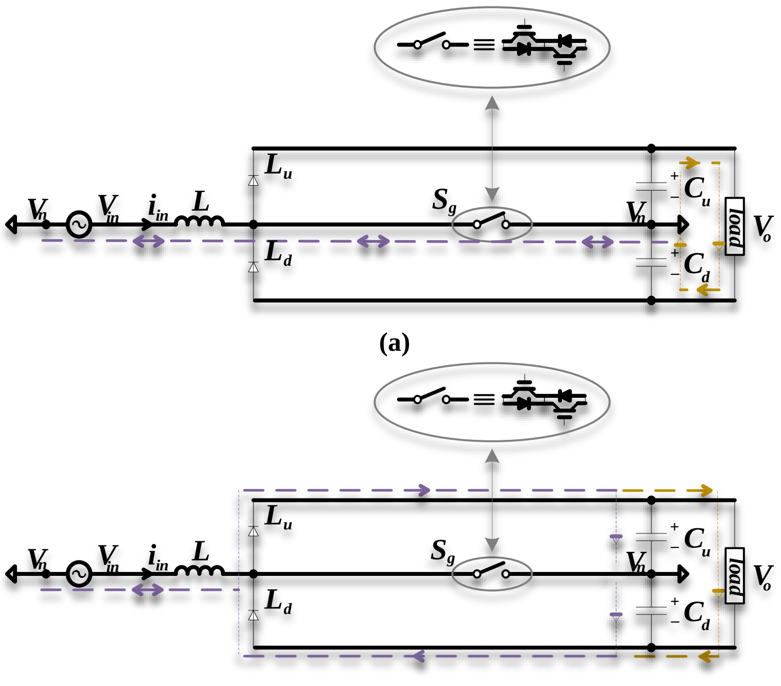


Fig. 3
a. Single-phase Vienna rectifier in shoot-through state
b. Single-phase Vienna rectifier in non-shoot-through state

Control scheme

Control scheme is presented in order to combine with sliding mode control. Reference voltage is used by SMC to balance the capacitor's voltage.

Sliding mode control:

Fig. 4 shows performance diagram of control system, which will merge with sliding mode in order to control the Vienna rectifier.

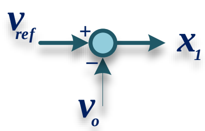


Fig. 4 Diagram of control system

The sliding surface, S,is defined as:

$$S = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 \quad (4)$$

That α_1, α_2 and α_3 are the sliding surfaceindexes. The logic state of power switch $S_g$is defined as follows:

$$u = \frac{1}{2}(1 + \mathrm{sign(S)}) \quad (5)$$

where, u is switching function. In order to control Vienna rectifier with PFC and output voltage balancing capabilities, the input current error x_1, the output voltage error x_2 and the integral of the voltage and current errors x_3 are considered as control variables which are expressed as:

$$i_{ref} = K\left[v_{ref} - v_o\right] = K\left[v_{ref} - v_o\right] \quad (6)$$

$$\begin{cases} x_1 = i_{ref} - i_L \\ x_2 = v_{ref} - v_o \\ x_3 = \int\left[x_1 + x_2\right]dt \end{cases} \quad (7)$$

K is the gain of the voltage error. A large value for K is chosen to improve dynamic response and to minimize the steady state voltage errors [30]. Dynamic model of Vienna rectifier based on Fig. 2 can be obtained as follows:

$$\begin{cases} \dot{x}_1 = \dfrac{d\left(i_{ref} - i_L\right)}{dt} = K\left[-\dfrac{dv_o}{dt}\right] - \dfrac{v_i - \bar{u}v_o}{L} \\ \dot{x}_2 = \dfrac{d\left(v_{ref} - v_o\right)}{dt} = -\dfrac{dv_o}{dt} \\ \dot{x}_3 = x_1 + x_2 = K\left[v_{ref} - v_o\right] - i_L + v_{ref} - v_o \end{cases} \quad (8)$$

$\bar{u} = 1 - u$ is considered to be complementary logic of u. v_i and v_o are instantaneous input and output voltages. L donates inductor of the converter. The equivalent control signal of the SM current controller when applied to the Vienna rectifier is obtained by solving (9).

$$\frac{dS}{dt} = \alpha_1 \dot{x}_1 + \alpha_2 \dot{x}_2 + \alpha_3 \dot{x}_3 = 0 \quad (9)$$

which gives

$$uv_o = \left[v_{ref} - v_o\right]\left[L\frac{\alpha_3}{\alpha_1}K + L\frac{\alpha_3}{\alpha_1}\right] - \frac{dv_o}{dt}\left[LK + \frac{\alpha_2}{\alpha_1}\right] - \frac{\alpha_3}{\alpha_1}Li_L + v_o - v_i \quad (10)$$

where,

$$K_1 = L\frac{\alpha_3}{\alpha_1}K + L\frac{\alpha_3}{\alpha_1} \quad (11)$$

$$K_2 = LK + \frac{\alpha_2}{\alpha_1} \quad (12)$$

$$K_3 = \frac{\alpha_3}{\alpha_1}L \quad (13)$$

Considering $v_{ramp} = uv_o$ and replacing uv_owithv_r then we have

$$v_r = K_1\left[v_{ref} - v_o\right] - K_2\frac{dv_o}{dt} - K_3 i_L + v_o - v_i \quad (14)$$

$$v_{ramp} = uv_o \quad (15)$$

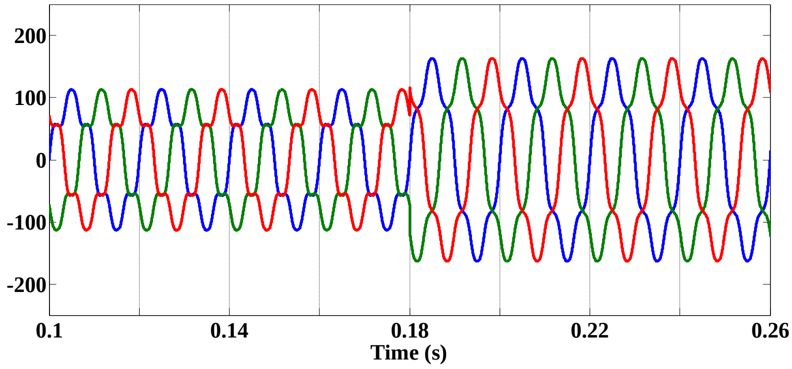
Because of fixed-frequency structure of presented SM controller, the chattering phenomenon, which is the important drawbacks of nonlinear controllers, will be eliminated.

Simulation result

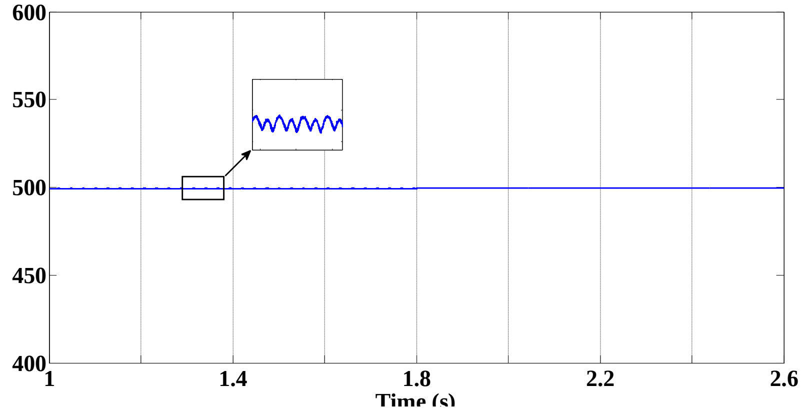
In order to verify performance of the proposed SMC on three-phase Vienna rectifier Matlab/Simulink is done. Simulations is operated in discrete mode with 1 µs step size. Parameters of Vienna rectifier are listed in Table I. *k*, orthogonal systems bandwidth factor is 0.3. In this case the input signal consist of main harmonic with 20% fifth harmonic, 5% seventh harmonic and 2% eleventh harmonic with 20.71% total harmonic distortion (THD). Main harmonic appear with peak voltage of 100 (V) and the frequency is 50 (Hz). Fig. 5(a) shows the distorted utility side voltage which supplies a Vienna rectifier and at 0.18 sec its fundamental component is increased up to 50%. The output DC voltage of Vienna rectifier is shown in Fig. 5(b). It can be seen from this figure that the output voltage remains constant in its reference value (500v) despite of input voltages changing.

Table I Tested system parameters

R_{Load}	150 (Ω)
L	1 (mH)
$V_{i(peak)}$	100 (V)



(a)



(c)

Fig. 8 Simulation results for three-phase grid connected Vienna rectifier with distorted input voltage (Fundamental voltages are increased 50% at t = 0.18 s)

a. Grid side voltage

b. Output DC voltage

These results verify the proper performance of presented control system based on combination of SMC and orthogonal systems.

Conclusion

Sliding mode control is applied to Vienna rectifier. Output voltage is controlled and stabilized in desire voltage. Despite of input distortions,output DC voltage is stabled on desire voltage that guarantee the performance of control system.

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Basics Of Kalman Filter And Position Estimation Of Front Wheel Automatic Steered Robot Car

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Abstract— In this paper, we have described the coordinate (position) estimation of automatic steered car by using kalman filter and prior knowledge of position of car i.e. its state equation. The kalman filter is one of the most widely used method for tracking and estimation due to its simplicity, optimality, tractability and robustness. However, the application to non linear system is difficult but in extended kalman filter we make it easy as we first linearize the system so that kalman filter can be applied. Kalman has been designed to integrate map matching and GPS system which is used in automatic vehicle location system and very useful tool in navigation. It takes errors or uncertainties via covariance matrix and then implemented to nullify those uncertainties. This paper reviews the motivation, development, use, and implications of the Kalman Filter.
Index Terms—Kalman Filter(KF),Extended Kalman Filter(EKF), Unscented Kalman Filter(UKF).

I. INTRODUCTION

The main objective of any on road Automatic Vehicle system is that It should be navigated with route information properly to the benefit of the user by relating vehicle location to its surrounding .To be effective, the vehicle's position must be continuously maintained in real-time as position of automatic system changes with the time.

Currently there are many techniques available for positioning of automatic vehicle location system, such as (odometer and compass technique). But these techniques are not reliable (dead reckon) techniques [1],[2] and [3] because they require updates to overcome the disturbance which comes into the picture with time and distance. In odometer [4], fixed objects in the surrounding provide landmarks which are listed in a data base. The system calculates the angle to each landmark and then orients the camera. A Kalman Filter is used to correct the position and orientation of the vehicle from the error between the observed and estimated angle to each landmark. Also to overcome the limitation of GPS technique it will be used combined with map matching but it also has drawback with congested road and overcrowded building area. In this paper we are highlighting the significance of kalman Filter in automatic vehicle location system.

Rudolf E. Kalman gave the idea of kalman filter, the great use Kalman filter is due to its small computational requirement, recursive properties, and its status as the optimal estimator for non linear and linear systems with Gaussian error statistics [5]. Typical uses of the Kalman filter include smoothing noisy data and providing estimates of parameters of interest. Applications include global positioning system receivers, motors, robot and many more.

A. PROCESS MODEL OF THE SYSTEM

The Kalman filter model assumes that the state of a system at a time k evolved from the prior state at time k-1 according to the equation

$$\mathbf{X}(k) = \mathbf{A}(k)\,\mathbf{x}(k-1) + \mathbf{B}(t)\,\mathbf{u}(k) + \mathbf{w}(k) \qquad (1)$$

Where

- **X(*k*)** is the state vector containing the terms of interest for the system
(e.g., position, velocity, heading) at Time *k.*

- **U (*k*)** is the vector containing any Control inputs (steering angle, throttle Setting, braking force).

- **A (*k*)** is the state transition matrix which applies the effect of each system state parameter at time *k*-1 on the system state at time *k* (e.g., the position and velocity at time *k*-1 both affect the position at time *k*).

- **B (***k***)** is the control input matrix which applies the effect of each. control input parameter in the vector **u (***k***)** on the state vector (e.g., applies the effect of the throttle setting on the system velocity and position).

- **W (***k***)** is the vector containing the process noise terms for each parameter in the state vector. The process noise is assumed to be drawn from a zero mean multivariate normal distribution with covariance given by the covariance matrix **Q (***k***)**.

B. Measurement Model Of The System

$$\mathbf{Y}\,(k) = \mathbf{C}\,(k)\,\mathbf{x}\,(k) + \mathbf{v}\,(k) \qquad (2)$$

Where

- **Y (***k***)** is the vector of measurements

- **C (***k***)** is the transformation matrix that maps the state vector parameters into the measurement domain.

- **V (***k***)** is the vector containing the measurement noise terms for each

observation in the measurement vector. Like the process noise, the measurement noise is assumed to be zero mean Gaussian white noise with covariance **R (***k***)**.

II.KAMAN FILTER ALGORITHM

Kaman filter complete its operation in three stages.
1.It predicts the system evolution by using prior knowledge in (k-1).
2. It measures the output in time (k).
3. It update measured output in time (k).
Kalman filter assumes that all predicted posterior density point at ever time step is Gaussian function and hence it is parameterized by mean and covariance.

A. Propagation stage

$$\hat{X}(k+1)/(k) = A(k)\,\hat{X}\,(k) \qquad (3)$$

$$P\,(k+1)/(k) = A\,P\,(k)/(k)\,A^T + Q \qquad (4)$$

And

$$[\omega(k)\omega(k)T] = \boldsymbol{Q}$$

B. Measurement Stage

- $\mathbf{Y}\,(k) = \mathbf{C}\,(k)\,\mathbf{x}\,(k) + \mathbf{v}\,(k) \qquad (10)$

C. Correction and Update Stage

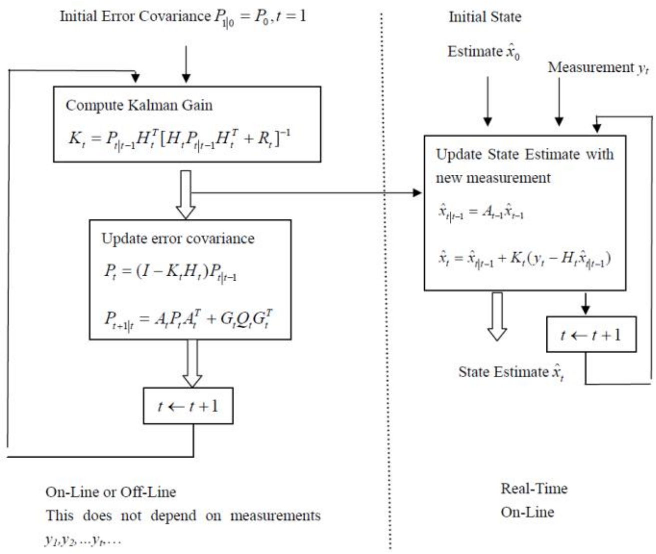
$$K\,(k+1) = \boldsymbol{P}(k+1)/(k)C^T\,[C\boldsymbol{P}(k+1)(k)\,C^T] + R^{-1} \qquad \ldots\ldots\ldots\ldots\ldots(11)$$

- $P\,(k+1)/(k+1) = (\boldsymbol{I} - \boldsymbol{K}(k+1)C)\boldsymbol{P}(k+1)/(k) \qquad \ldots\ldots\ldots\ldots\ldots(12)$

$$\hat{X}(k+1)/(k+1) = [\hat{X}(k+1)/(k) + \boldsymbol{K}(k+1)(Y(k) - C\,\hat{X}(k+1)/(k))] \qquad \ldots\ldots\ldots\ldots\ldots(13)$$

So by introducing the term kalman gain **K** we can update our predicted equation i.e. whatever will be the error in these equation can be compensated by selecting computing the kalman gain from measurement.

D. Recursive Kalman Gain



III. Types Of Kalman Filter

A. Extended Kalman Filter (EKF)

As we know no system in practical world is linear, In extended kalman filter, we need to first linearize the system by taking the jacobian of state transition matrix(A) and measurement matrix (C) then we apply operation of prediction and filtering.

EKF for nonlinear processes

Prediction Step

$$\hat{X}(k+1)/(k)=\hat{X}(k)/(k)+\int_{k\Delta t}^{(k+1)\Delta t} f(x(\tau),u_k)d\tau \qquad (14)$$

Covariance Matrix

$$P(k+1)/(k) = A(k)\,P(k)/(k)\,A^T(k) + Q(k) \qquad (15)$$

Correction Step

$$\hat{X}(k+1)/(k+1) = [\hat{X}(k+1)/(k) + \boldsymbol{K}(k+1)(Y(k) - g\,\hat{X}(k+1)/(k))]$$
…………(16)

Problems with EKF

1. Uses linearized model[6] and[7] for computing covariance matrix (uncertainty) in estimates
2. Uses a linear estimator for obtaining updated estimates
3. Unconstrained estimator – Clipping has been adopted as a possible approach for including constraints.
4. Has been shown to generate poor estimates
5. Lengthy periods of over or under estimation, demonstrated in some cases to be 2 orders of magnitude.

B. Unscented Kalman Filter (UKF)

In unscented kalman filter, we don't need to linearize the system. We predict the pdf by sigma point approach [6] and calculate their weighted mean and covariance. On the basis of their weighted mean and covariance we select appropriate point. If 'n' is an order of system then we select 2n+1 sigma point [8].

2n+1 sigma point selection

$$X_0 = \bar{X} \qquad W_0 = (k)/(k+n) \qquad (17)$$

- $X_i = \bar{X} + \sqrt{((n+k)P_{xx})}_i \qquad W_i = 1/2(k+n)$ ………(18)

And

- $X_{i+n} = \overline{X} - \sqrt{((n+k)P_{xx})}_i$ $\quad W_{i+n} = 1/2(k+n)$ ………(19)

2n+1 sigma points are propagated as

- $Y_i = g\,(X_i)$ (20)

Mean is calculated

- $\overline{Y} = \sum_{i=0}^{2n} W_i Y_i$ (21)

Covariance is calculated

- $P_{yy} = \sum_{i=0}^{2n} W_i [Y_i - \bar{Y}][Y_i - \bar{Y}]^T$ (22)

IV. Problem statement

Front-wheel steered robot modified:

States: x: x co-ordinate,
y: y co-ordinate,

ψ: heading angle,

α: steering angle,

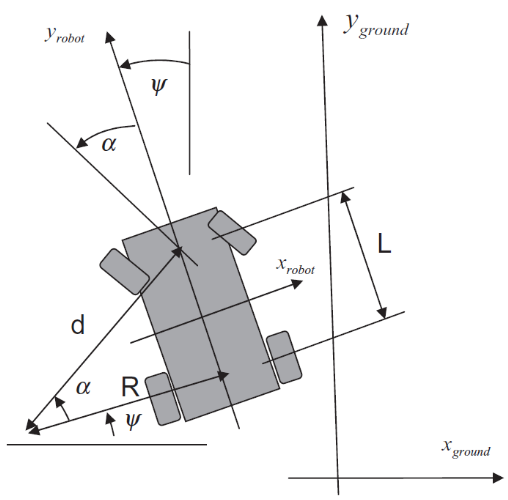
v: velocity

Model:
State equations:

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\psi} \\ \dot{\alpha} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} v\cos(\psi) \\ v\sin(\psi) \\ v\tan(\alpha) \\ 0.005 \\ 0.098e^{\frac{-t}{5}} \end{bmatrix}$$

Output: $z = \begin{bmatrix} x \\ y \end{bmatrix}$

Initial conditions: [0, 0, 0, 0, 0], t =[0, 15]



For some navigation application, we need to know the precise position of vehicles when it turns, for using GPS along with map matching system we need appropriate updated position of car so if vehicle misses its position i.e. the desired trajectory then kalman filter will remove the error and take vehicle onto its desired trajectory. For automatic vehicle system it is very important that it must know its location so that it may operate autonomously and reach the required destination.

In this problem we have to find the position of car as we have been given the state equation (Process model) and output measurement equation. In process model there are total five parameter. First two parameter x and y are for coordinates of a car i.e. position of the car. Ψ is heading angle which changes w.r.t steering angle α. In process model we can clearly see that position of car is dependent on the velocity v and the heading angle ψ, but in this problem our aim to predict and update the position of the car(x and y coordinate) as shown in measurement equation.
If we implement this problem using extended kalman filter (EKF), we need to linearize the matrix 'A' by taking its jacobian, then predict the position. If we take Unscented kalman filter (UKF) then no need for linearization, we will predict the sigma point depend on the order of the process model. In our problem the order of the system is 5 then UKF will predict 6 point [8]and out of them it will select 1 point on the basis of their weighted mean and covariance and then filtering operation.
Initially we will consider variance matrix 'w' as null matrix therefore our initial covariance matrix will also be null matrix

$$Q = \begin{pmatrix} 0 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 0 \end{pmatrix}$$

Order of matrix depend upon the parameter of process model.

EkF Implementation

Because of the nonlinear case that is encountered here we also have used an EKF that linearizes the current mean and covariance. The EKF has been applied to the same robot model as the one used for the KF case. The EKF algorithm is described in the following:

A. The prediction step:
By using procees model we will predict the next step.

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\psi} \\ \dot{\alpha} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} v\cos(\psi) \\ v\sin(\psi) \\ v\tan(\alpha) \\ 0.005 \\ 0.098e^{\frac{-t}{5}} \end{bmatrix}$$

First linearize it by taking its jacobian

$$J = \begin{matrix} 0 & 0 & -vsin\psi & 0 & 0 \\ 0 & 0 & vcos\psi & 0 & 0 \\ 0 & 0 & 0 & vlogsin\alpha & tan\alpha \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{matrix}$$

Where J is the jacobian of 'F'.

From output equation we have been given C=[1 1 0 0 0] which is Clearly indicating that we have to predict and measure the coordinate of the car i.e the position of the car.

B. Observation and update:
In this step we need to compute the Kalman gain
Refer equation (11),(12) and(13)

Result

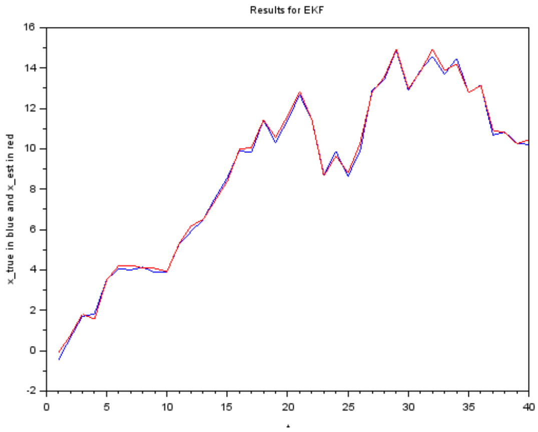


Fig 2:EKF Result for time period t=0.5
On x-axis t in second ,

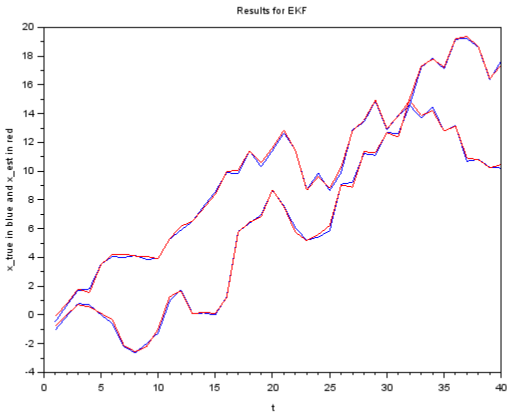
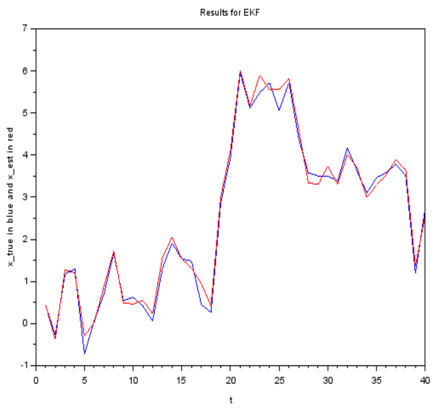


Fig 3:EkfF Result fortime period t=0.7
On x-axis t in second
Y-axis x_estimated in red and x_true in blue



On x-axis t in second
Y-axis x_estimated in red and x_true in blue

Conclusion

We have presented the basic of kalman filter and successfully implemented the kalman filter on front wheel automatic steered robot and got the results in scilab, as it is clearly showing on y-axis that x_estimated in (blue line) updated by kalman filter and bringing it back to the x_true in (red line) by compensating the posterior covariance.

By making use of klaman filter together with GPS and map matching technique we can use it in automatic vehicles for trajectory tracking.

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