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A Zeta Type PFC Converter with Flexible Output Voltage and Improved Conversion Efficiency

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ABSTRACT:

This paper has a flexible output voltage and improved conversion efficiency of a Zeta-type power factor correction (PFC) provides converter. Sinusoidal input current and the output of the proposed PFC converter includes a wide range of DC voltage, and the output voltage is either lower or higher than the peak AC input voltage, which is very suitable for high-power applications, eg, plug-in hybrid electric vehicle charging systems. Moreover, the responsible DC / DC buck converter power stage input is only a partial rather than a full range of input power, and the need to process the total capacity of the system may be improved. By proper control of a buck converter, which is a single-phase AC / DC is inherent in the system is also possible to reduce the double line frequency ripple power, and as a result of the end of the load voltage is very stable. This is a very fast dynamic response of the control loop and the system is insensitive to external disturbances so.

Single-phase AC / DC converters are one of the most common energy conversion systems and many industrial as well as residential applications, such as variable speed drives, electric vehicle chargers and power supplies can be found for consumer electronics. IEC61000-3-2 harmonic limits, high power factor and sinusoidal current control period as to fulfill the more stringent grid codes beyond their power ratings of 75 W is required for all such applications [1]. Currently, single-phase power factor correction (PFC) converters such rules because of their simplicity, cost effectiveness, and the ability to better ensure compliance with the shaping of a very popular solution. However, most of existing single-phase PFC boost converters, AC Input type and only provides an output voltage that is higher than the peak voltage [2] - [6]. In fact, a wide range of output voltage plug-in hybrid electric vehicle (PHEV) charging systems required in some applications, such as battery packs terminal voltage 100 V and 600 V, [7], depending on their configuration and switch between the name of the state- of-charge. In this case, the second stage DC / DC buck converter to further reduce the total capacity of the system is undoubtedly the PFC output voltage, step down, to be implemented.

POWER FACTOR CORRECTION (PFC)

An electricity distribution system, an electric utility's power load will fall one of three categories; Resistive, inductive or capacitive. Many industrial facilities, the most common uses of electric "motor." There are examples of inductive loads, transformers, fluorescent lighting and AC Induction Motors. Inductive loads are allowed to work in the motor winding a conductive coil that generates an electromagnetic field.

Two different types of power required to operate the motor, all inductive loads:

- Active Power (measured in kW or kW) - the energy to produce motive force
- Reactive power (left) - the motor's magnetic field energizes.
- Distribution system operating power from the two active (work) and reactive (non-working) is composed of the elements.

Reduction of heating losses in transformers and distribution equipment longer equipment life

- Stabilized voltage levels
- Increased capacity of your existing system and equipment
- Improved profitability
- Lowered expenses

Power Quality

Contemporary container crane industry, like many other industry sectors, often the bells and whistles that can be achieved, colorful diagnostic displays, high-speed performance and is enamored levels of automation. These features and their directly or indirectly related to the operation of the terminal, the key to effective computer-based enhancements, despite the problems, we must not forget that building upon the foundation. Performance requirements continue to increase.

Power Quality Problems

For the purpose of this article, we shall define as the power quality problems:

"When a power failure or disoperation of customer equipment problem is that the economic burden of the user compose or produce adverse effects on the environment."

When applied to the container crane industry, electrical energy, which can degrade the quality of some of the issues:

- Power factor
- Harmonic Distortion
- Voltage transients
- Voltage sags or dips
- Voltage interval

In many cases, the description of those involved with the collection and use of container cranes BILLINGS do not pay, or that it did not consider the subject of someone else, it may not be cognizant of these issues. As a result, the container crane, such as descriptions of the power factor correction and / or harmonic filter, power quality standards may not be conclusive. Also, do not properly define the standards and power quality equipment that does not need many explanations. Early in the process of making the specification of the crane:

The Benefits of Power Quality

Economics of the operation of the container terminal in the environment affect the electrical quality of the terminal, the terminal can affect the reliability of the equipment, and that will affect other users of utility services. Each of these concerns are explored in the following paragraphs.

1. Effect

The effect of the economic incentive for power quality is foremost a container terminal operators. Has a significant economic impact, and can be expressed in many ways:

A. Power factor penalties

BILLINGS's monthly utility companies have used a number of low power factor penalties. There is no industry standard when utility companies. Use one of the metering methods and computational power factor penalties will vary from company to another. Some utility companies actually use the meter kVARkVAR times the number of hours consumed and the establishment of a fixed rate. KVAR demand for other utility companies to monitor and calculate the power factor. Demand for power factor falls below the value of the fixed limit, will be charged a penalty in the form of adjusting the peak demand charges.

The container terminal equipment, servicing the utility companies do not invoke the power factor penalties. However, the port is a defined demand for their service agreement still need to be met in the minimum power factor. The utility company to continuously monitor the usage and monthly utility power factor or kVAR BILLINGS not reflect them; however, they reserve the right at any time to monitor the port service. Container terminals on the east coast of the service in the USA to supply power to a utility company, does not reflect on their monthly power factor penalties in BILLINGS, however, the terminal of their service agreement reads as follows:

B. System losses

Harmonic currents and non-weight, low power factor by power factor penalties as a result of not only, but also to increase the power losses in the distribution system. These losses appear as a special item in your monthly utility billing, but you have to pay each month. Container cranes, are the leading causes of harmonic currents and low power factor.

c. Power Service Initial Capital Investments

Distribution system design and installation of electrical systems for the terminal capability upgrades for new terminals, as well as the change, the higher the price, is specialized in high and medium voltage equipment. Transformers, switchgear, feeder cables, trailing cables, cable reel, collector bars, etc. should be sized based on the demand KVA. KVA demand relates directly to the amount of the cost of the equipment. Refers to the relationship, KVA power factor is inversely proportional to the amount of demand, ie, a low power factor load is the same for kW demand high KVA.

EQUIPMENT RELIABILITY

Poor power quality reduces the life of the machine or equipment and components affecting reliability. Harmonics, voltage transients, and voltage sags and swells, all power quality problems are in the system and are all interdependent.

Harmonics voltage transients induced by the balance of power, influence factor, SCR DC variable speed drives in the harmonic current injection that generates the same things responsible for poor power factor, voltage sags and swells with confidence to create a variety of the same drives, power factor. Harmonic distortion, harmonic currents, and using filters specifically designed to reduce the effects of the line ringing line.

THE POWER SYSTEM ADEQUACY

When considering the installation of additional cranes to the existing power distribution system, a power system analysis should be done to determine the adequacy of the system to support additional crane loads. Due to the correction of the existing power distribution and power quality systems to be connected to the new or disqualification under the auspices of the cranes can be moved. In other words, without the risk of problems with power quality equipment in addition to otherwise support the additional cranes would be inconsistent with the existing electrical distribution system, applies to a workable scenario.

ENVIRONMENT

No problem, we can be as important an impact on the environment and power quality. Reduction of system losses and low demand, a reduction in power plant emissions and reduced our consumption of natural resources compared nm. The occupants of this planet, our natural resources and improve the quality of our air, it is our responsibility to encourage conservation measures.

Inverter:

Inverter appropriate transformers, switching and control circuits and frequency of the desired size with the use of an alternating current to power the electronic circuit is a direct current power to change. Modern AC motor inverters, and uninterruptible power supplies find their application. Static inverters have no moving parts and a wide range of applications, the bulk of the high-voltage direct current energy to transport large electric utility applications, computers are used from

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small switching power supply. Inverters, solar panels or batteries typically used to supply AC power from DC sources.

The circuit diagram of CSI is shown in fig

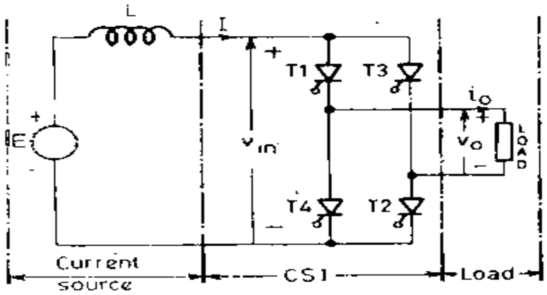

Fig 3.6: Power circuit diagram of CSI

CSI to DC I input current constant. T1, T2 when the load current is equal to the positive and I. T3, T4, when the load current is negative on. The output frequency of the triggering pairs T1, T2, T3, and T4 by controlling the frequency of the change. It is equal to the output current DC Input current I. The outbreak appears to be a square wave C. It is a load capacitor = C dv0 / dt I0 be equipped with a capacitor is known. I0 is constant, the slope should be consistent with each half cycle. The slope of the CSI when the input voltage Vin = V0 T1, T2 behavior and when Vin = -vo T3, T4 behavior, such as from 0 to T / 2 positive and T / 2 to be negative. The output voltage or current frequency f, such as vo = 1 / T of the input voltage has a frequency 2F. CSI to DC Input is always in the same direction.

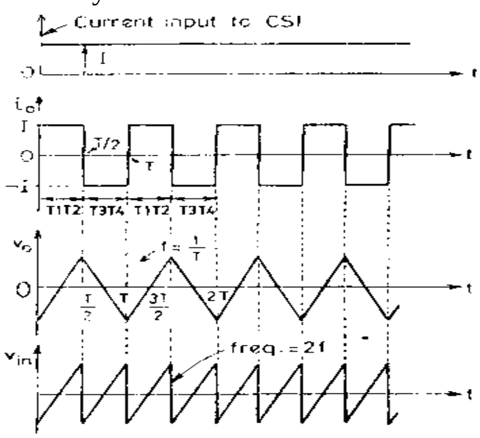

Fig 3.7 Waveforms for current source inverter

Half Bridge VSI:

Here are two large capacitors are required to provide a neutral point N half bridge VSI, power topology, such as = 2 maintains a constant voltage of each capacitor. The balance of the current balance in order to lower injected by inverter operation, large capacitors (C. and CY) is necessary because the set. It has two switches, DC Link to a short circuit across the voltage source vi S. and because the product can not be simultaneously SY clear. Both are shown in Table 14.1 defining (states 1 and 2) and an undefined (state 3) are switched state. DC And undefined condition of AC output voltage across the bus in order to avoid a short circuit, allowing the technique to be always at the top of any immediate or inverter has to ensure that at the switch at the bottom of the leg.

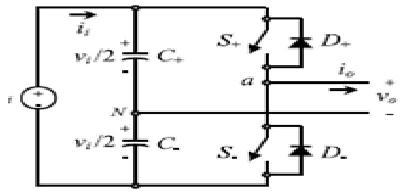

Fig 3.8: Single Phase Half Bridge VSI

The half-bridge inverter shown in Fig shows the waveforms associated with the ideal. 14.2. Switches S. and SY states allow the technique, which in this case is described as a carrier-based PWM.

Full-Bridge VSI:

The power topology of a full-bridge VSI. This inverter is similar to the half-bridge inverter; however, a second leg provides the neutral point to the load. As expected, both switches S1. and S1ÿ (or S2. and S2ÿ) cannot be on simultaneously because a short circuit across the dc link voltage source vi would be produced. There are four defined and one undefined

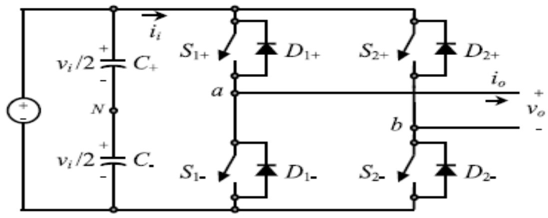

Fig 3.9: Single Phase Full Bridge VSI

AC output voltage so as to be capable of defining always, defined the situation should be avoided. DC And undefined condition of AC output voltage across the bus in order to avoid a short circuit, allowing the method should ensure that either the top or bottom of each leg is in any case the switch. AC output voltage values of the half-bridge DC, which is twice that of the VSI topology Link value vi, take a look at the up. Modulates a number of methods have been developed that are applied to the full bridge VSIs .

1. a buck converter, the step-down converter

Turning on the transistor circuit inductor and put an end voltage Vin. Inductor current will tend to cause the voltage to rise. When the transistor is turned off, the current through the inductor continues, but now flowing through the diode. We present the first inductor, and therefore do not reach the zero voltage at VX is just the voltage across the diode is conducting now assume that at the time of completion. The average voltage of the transistor at an average of VX depends on the amount of time provided by the continuous flow inducement.

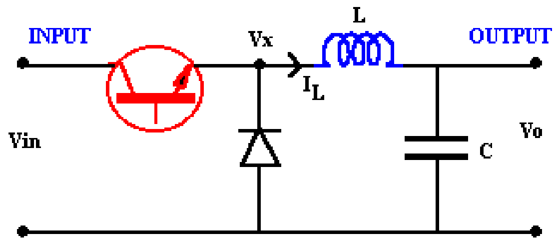

Fig 3.10: Buck Converter

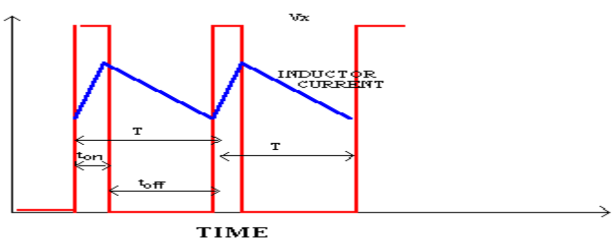

Fig 3.11: Voltage and current changes

To analyze the voltages of this circuit let us consider the changes in the inductor current over one cycle. From the relation

$$V_x - V_o = L\frac{di}{dt}$$

The change of current satisfies

$$di = \int_{ON}(V_x - V_o)dt + \int_{OFF}(V_x - V_o)dt$$

A. Continuous and discontinuous transition

The current in the inductor L is always positive when the transistor T1 or the need to either diode D1. Inductor current is then forced to either of these conditions is not always zero when the output voltage for continuous conduction voltage VX r 0 to either win the game or not. In this period of transition, the current just reaches zero. During the ON time Vin-$V_{out}$is across the inductor thus

$$I_L(peak) = (Vin - Vout)\cdot\frac{t_{ON}}{L} \quad (1)$$

The average current which must match the output current satisfies

$$I_L(average\ at\ transition) = \frac{I_L(peak)}{2} = (Vin - Vout)\frac{dT}{2L} = Iout(transition)$$

(2)

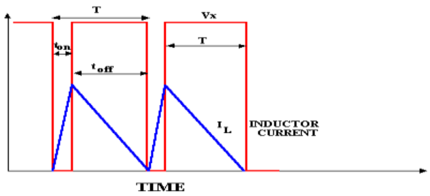

Fig 3.12: Buck Converter at Boundary

If the input voltage is constant the output current at the transition point satisfies

$$Iout(transition) = Vin\frac{(1-d)d}{2L}T \quad (3)$$

b.Voltage Ratio of Buck Converter (Discontinuous Mode)

As for the continuous conduction analysis we use the fact that the integral of voltage across the inductor is zero over a cycle of switching T. The transistor OFF time is now divided into segments

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of diode conduction d_dT and zero conduction d_oT. The inductor average voltage thus gives

$$(V_{in} - V_o) DT + (-V_o) d_dT = 0 \quad (4)$$

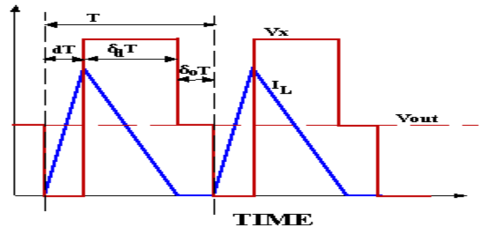

Fig 3.13: Buck Converter - Discontinuous Conduction

$$\therefore \frac{Vout}{Vin} = \frac{d}{d + \delta_d} \quad (5)$$

for the case $d + \delta_d < 1$. To resolve the value of δ_d consider the output current which is half the peak when averaged over the conduction times $d + \delta_d$

$$Iout = \frac{I_L(peak)}{2} d + \delta_d \quad (6)$$

Considering the change of current during the diode conduction time

$$I_L(peak) = \frac{V_0(\delta_d T)}{L} \quad (7)$$

Thus from (6) and (7) we can get

$$I_{out} = \frac{V_0 \delta_d T \cdot (d + \delta_d)}{2L} \quad (8)$$

Using the relationship in (5)

$$Iout = \frac{Vin\, d\, \delta_d T}{2L} \quad (9)$$

and solving for the diode conduction

$$\delta_d = \frac{2L\, Iout}{Vin\, d\, T} \quad (10)$$

The output voltage is thus given as

$$\frac{Vout}{Vin} = \frac{d^2}{d^2 + \left(\frac{2L\, Iout}{Vin\, T}\right)} \quad (11)$$

Defining $k^* = 2L/(V_{in} T)$, we can see the effect of discontinuous current on the voltage ratio of the converter.

As seen in the figure, once the output current is high enough, the voltage ratio depends only on the duty ratio "d". At low currents the discontinuous operation tends to increase the output voltage of the converter towards V_{in}.

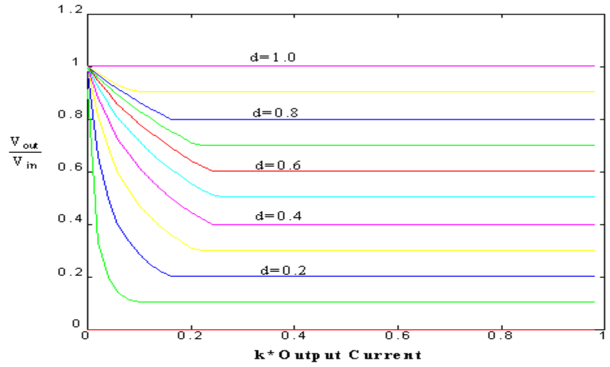

Fig 3.14: Output Voltage vs Current

2. Boost converter step-up converter

The schematic in Fig.3.6.2 shows the basic boost converter. This circuit is used when a higher output voltage than input is required.

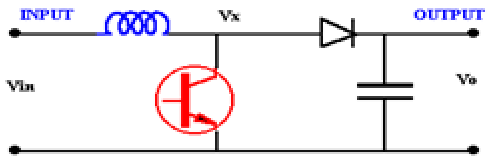

Fig 3.15: Boost Converter Circuit

While the transistor is ON $V_x = V_{in}$, and the OFF state the inductor current flows through the diode giving $V_x = V_o$. For this analysis it is assumed that the inductor current always remains flowing (continuous conduction). The voltage across the inductor is shown in Fig. 2.7 and the average must be zero for the average current to remain in steady state

$$Vin\, t_{on} + (Vin - Vo) t_{off} = 0$$

This can be rearranged as

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$$\frac{Vo}{Vin} = \frac{T}{t_{off}} = \frac{1}{(1-D)}$$

And for a lossless circuit the power balance ensures

$$\frac{Io}{Iin} = (1-D)$$

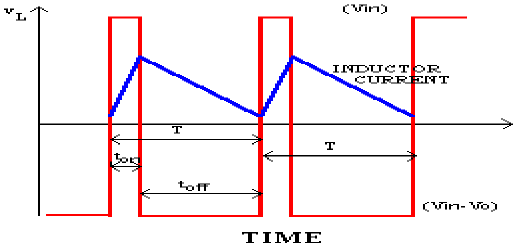

Fig 3.16 Voltage and current waveforms (Boost Converter)

Since the duty ratio "D" is between 0 and 1 the output voltage must always be higher than the input voltage in magnitude. The negative sign indicates a reversal of sense of the output voltage.

3. Buck-boost converter

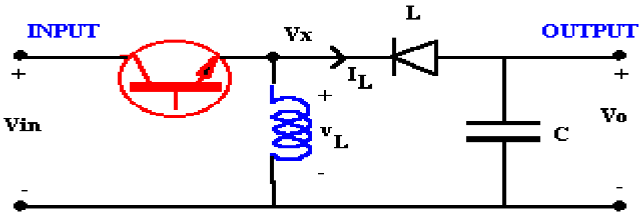

Fig 3.17: schematic for buck-boost converter

With continuous conduction for the Buck-Boost converter $V_x = V_{in}$ when the transistor is ON and $V_x = V_o$ when the transistor is OFF. For zero net current change over a period the average voltage across the inductor is zero

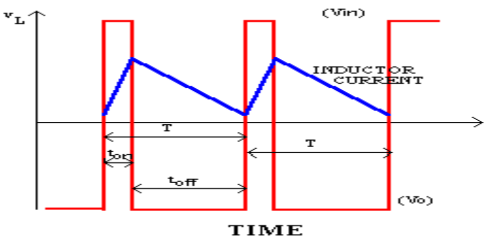

Fig 3.18: Waveforms for buck-boost converter

$$Vin\,t_{ON} + Vo\,t_{OFF} = 0 \quad \text{………….. (21)}$$

which gives the voltage ratio

$$\frac{Vo}{Vin} = -\frac{D}{(1-D)} \quad \text{………… (22)}$$

and the corresponding current

$$\frac{Io}{Iin} = -\frac{(1-D)}{D} \quad \text{……….. (23)}$$

The duty ratio "D" 0 and 1 between the size of the input voltage from the output voltage can vary between less than or more.

4. Comparison Converter

DC-DC converters is achieved through voltage ratios are summarized in Fig. Only a buck converter control (duty ratio) and a linear relationship between the output voltage 10. The notice shows. Or reducing the duty ratio of 50% of the buck-boost voltage ratio can be increased for the benefit of the unit.

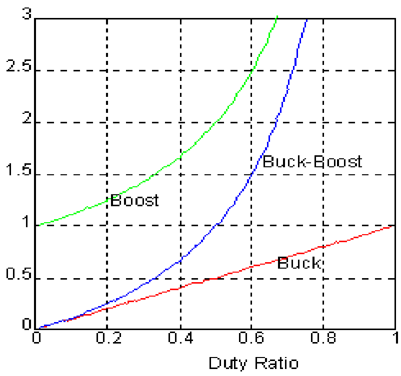

Fig 3.19: Comparison of Voltage ratio

5. Need for switching techniques:

- It reduces the size of the value and the filter inductances and capacitances. Until, it reduces the size of the transformer
- Reduce the switching loss
- High-density loss in power supplies

There are procedures that can be used for soft switching techniques to achieve these goals.

6. Types of switching methods:

- Hard exchange
- Soft Switching

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A) hard switching:

Semiconductor devices or zero crossing of the voltage or current waveforms are switched to look at other than hard switching.

A) Soft Switching:

Semiconductor devices are switched on or off at the zero crossing of the current soft switching waveforms look. There are two types of soft switching techniques commonly employed

1. Zero Voltage Switching (ZVS)
2. Zero Current Switching (ZCS)

B) hard switching:

Pressure refers to the behavior of the exchange of the hard switching power electronic devices. The trajectory of a hard switch on the device, the power converter is shown in Fig 3.6. During the turn and the turn-off, as a result of an electrical device with high switching losses and stress, at the same time is able to withstand high voltage and current.

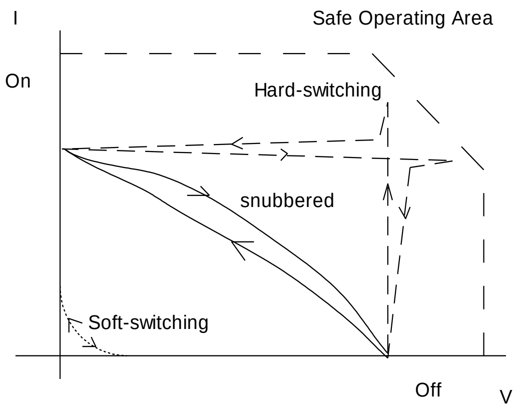

Fig 3.20: Typical switching trajectories of power switches

Dissipative passive snubbers are generally added to power circuits / power devices could be reduced dt dv / dt and so different, and switching loss and snubber circuits to be diverted to passive pressure. However, the maximum switching frequency of the switching power converter is limited to the loss is proportional to the frequency of the exchange.

Pulse-width modulation (PWM):

PWM current intermediate between fully and completely off the most effective way of providing. A typical power source when the switch is a simple electric switch provides full power. PWM-making made possible by modern electronic power switches is a relatively recent technique.

I. Sinusoidal Pulse Width Modulation (SPWM):

The two-level PWM inverter sinusoidal for the principle of the scheme Fig.1.6, where a three-phase sinusoidal modulating said carrier wave and triangular wave. The fundamental frequency component in the inverter output voltage can be controlled by amplitude modulation indexwhich is given by

$$m_a = \frac{\hat{V}_m}{\hat{V}_{cr}} \qquad (1.2)$$

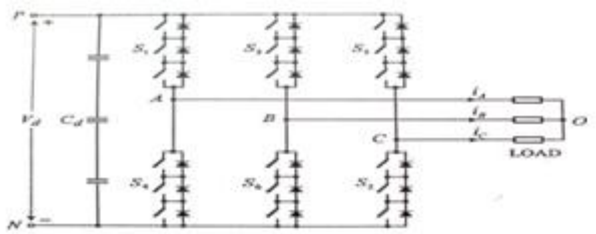

Fig 3.21: simple two level inverter

Where V_m and V_{cr} are the peak values of the modulating and carrier waves respectively. The amplitude modulation index m_a is usually adjusted by varying V_m while keeping V_{cr} fixed.The frequency modulation index is defined by

$$m_f = \frac{f_{cr}}{f_m} \qquad (1.3)$$

And a carrier frequency of the waves are able to.

A carrier wave is modulated with the operation of the switches is determined by comparing the waves. When the switch is a high-inverter leg. Therefore, the switch operates in a complementary manner to lower the switch. It is in the negative, DC The resulting voltage

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at a terminal of an inverter with respect to the bus terminal voltage, DC voltage is equal. From the <above and as shown in Fig.1.7 = 0, which is off. The two levels of the wave, and since we're 0, inverter is known as a two-level inverter.

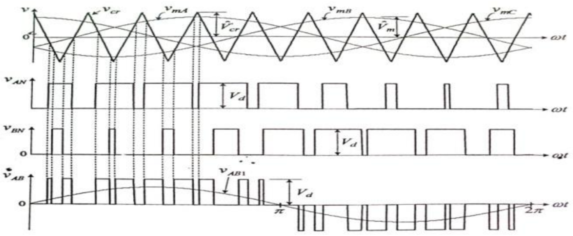

Fig 3.22 Sinusoidal Pulse Width Modulation (SPWM)

The switching frequency of the active switches in the two-level inverter can be found from

$$f_{sw} = f_{cr} = f_m \times m_f \quad (1.4)$$

For example, Fig.1.7 fundamental frequency of the cycle consists of nine pulses. Each pulse is produced by the turning on and off. The fundamental frequency of 50Hz, with the result that the switching frequency, the carrier frequency = 50 x 9 = 450Hz, is. Switching frequency of the device, which is not always equal to the carrier frequency should be noted that the multi-level inverters.

PWM is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices. When in PWM regulation, the current from the solar array tapers according to the battery's condition and recharging needs Consider a waveform such as this: it is a voltage switching between 0v and 12v. It is fairly obvious that, since the voltage is at 12v for exactly as long as it is at 0v, then a 'suitable device' connected to its output will see the average voltage and think it is being fed 6v - exactly half of 12v.

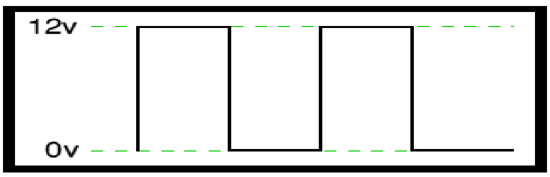

Fig 3.23: voltage switching between 0v and 12v

Similarly, if the switches keep the voltage at 12 for 3 times as long as at 0v, the average will be 3/4 of 12v - or 9v, as shown below

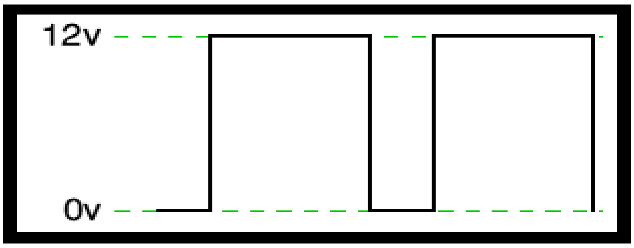

Fig 3.24: the average voltage switching will be 3/4 of 12v - or 9v

And if the output pulse of 12v lasts only 25% of the overall time, then the average is

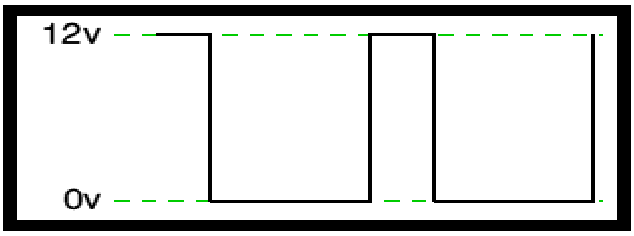

Fig 3.25: the average voltage switching will be lasts for ¼ of over all time

By varying - or 'modulating' - the time that the output is at 12v (i.e. the width of the positive pulse) we can alter the average voltage. So we are doing 'pulse width modulation'. I said earlier that the output had to feed 'a suitable device'. A radio would not work from this: the radio would see 12v then 0v, and would probably not work properly. However a device such as a motor will respond to the average, so PWM is a natural for motor control.

ii.Pulse Width modulator

So, how do we generate a PWM waveform? It's actually very easy, there are circuits available in the TEC site. First you generate a triangle waveform as shown in the diagram below. You compare this with a d.c voltage, which you adjust to control the ratio of on to off time that you require. When the triangle is above the 'demand' voltage, the output goes high. When the triangle is below the demand voltage, the output goes low

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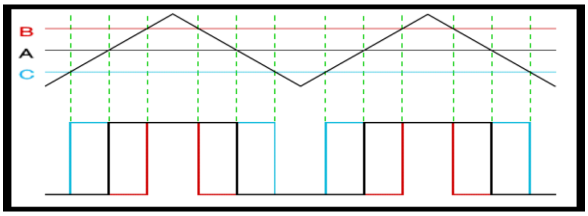


Fig 3.26: Pulse with modulator wave form genaration.

When the demand speed it in the middle (A) you get a 50:50 output, as in black. Half the time the output is high and half the time it is low. Fortunately, there is an IC (Integrated circuit) called a comparator: these come usually 4 sections in a single package. One can be used as the oscillator to produce the triangular waveform and another to do the comparing, so a complete oscillator and modulator can be done with half an IC and maybe 7 other bits.

Traditional solenoid driver electronics rely on linear control, which is the application of a constant voltage across a resistance to produce an output current that is directly proportional to the voltage. Feedback can be used to achieve an output that matches exactly the control signal. However, this scheme dissipates a lot of power as heat, and it is therefore very inefficient.

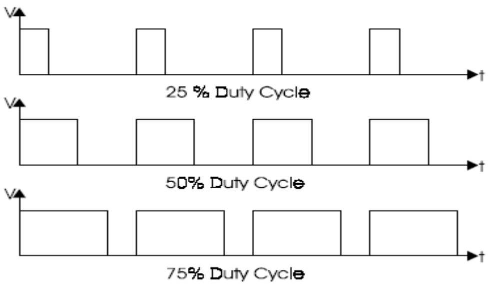
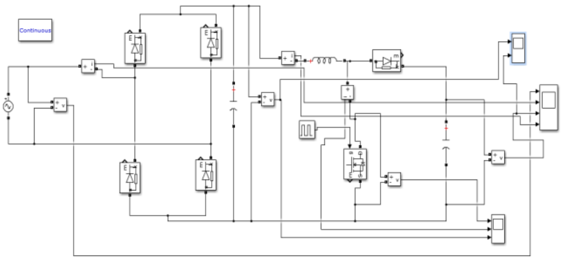
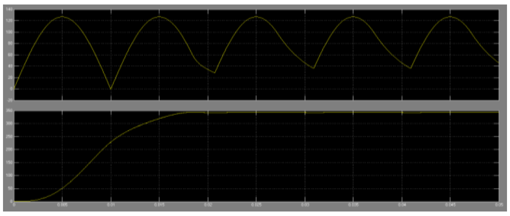


Fig 3.27. : Duty cycle variations from 0 to 1

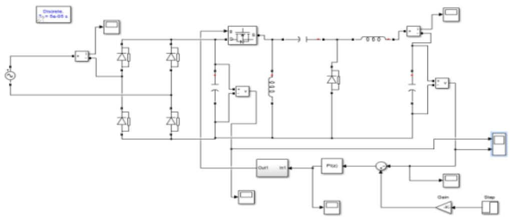
SIMULATION RESULTS



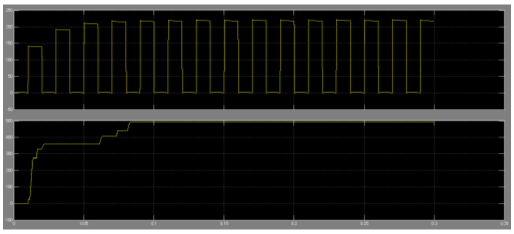
Base Paper Simulation Circuit



Output DC Voltage: a) before to PFC converter b) after PFC converter



Extension Simulation Circuit



Output DC Voltage: a) before to Zeta based PFC converter b) after Zeta PFC converter

CONCLUSION

A Zeta based Power Factor Correction (PFC) converter is proposed in this paper. It is observed that the proposed converter is yielding the improved results than the existed configuration and also it is giving improved conversion efficiency. The proposed Zeta based PFC DC-DC converter is validated through simulation results.

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