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A Three Phase Power Conversion Based on Single Phase and PV System Using Cockcraft-Walton Voltage

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ABSTRACT

The three phase induction motor is operated from distributed system and PV system through the Cockcroft - Walton voltage multiplier (CWVM) without using step-up transformer. Initially single phase is given, when a power failure occurs load can automatically runs at the same three phase power using renewable resource solar. The power is converted and inverted to produce three phase voltage and it is feed on to the three phase induction motor. The proposed converter is quite suitable for applying low-input dc voltage and to produces high dc output. It provides continuous input current to load with low voltage and current ripple and also reduces the leakage current in efficient way. Voltage stress on the all switching device, diodes, and capacitors are lower than that of all other types. The structure of the proposed converter is very simple. A three phase inverter to convert the DC voltage to three phase AC voltage using a Space vector pulse width modulation (SVPWM) technique. It can produce a pure sinusoidal waveform compare to other techniques.

Keywords - CWVM – Cockcroft-Walton Voltage Multiplier, Distributed system, SVPWM – Space Vector Pulse Modulation.

1. INTRODUCTION

There is a trend toward modular structured renewable/distributed system concepts in order to reduce costs and provide high reliability. Photovoltaic energy has become more and more attractive among all renewable energy resources, because it is noiseless, pollution-free, nonradioactive, and inexhaustible. The photovoltaic cell and distributed system have been considered attractive choices. The output voltages are produced from both the sources accordingly to their need and availability using sugar cube relay Fig.1. Block diagram. In addition to the mentioned applications, a high step-up dc-dc converter is also required by irrigational field and many small scale industrial applications to give an uninterruptible power supplies.

Non-isolated dc–dc converters as the classical boost, can provide high step-up voltage gain, but with the penalty of high voltage and current stress, high duty-cycle operation and limited dynamic response. The diode reverse recovery current can reduce the efficiency when operating with high current and voltage levels. There are some non-isolated dc–dc converters operating with high static gain, as the quadratic boost converter but additional inductors and filter capacitors must be used and the switch voltage is high.

However, recently new non-isolated dc–dc converter topologies were proposed that it is possible to obtain high static gain, low voltage stress and low losses, improving the performance with relation the classical topologies.

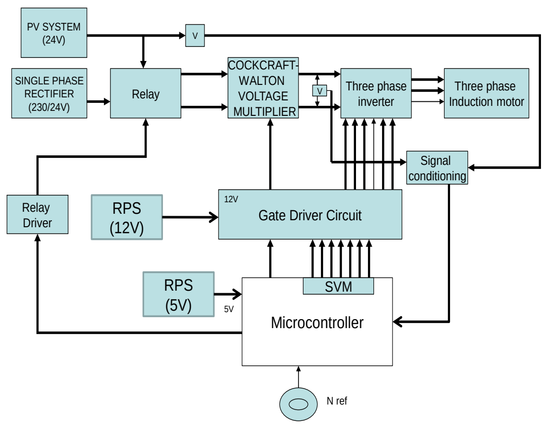

Fig 1. Block diagram

In push pull converters it achieves a high voltage gain, the leakage inductance of the transformer is relatively increased due to the high number of winding turns. Consequently, the switch is burdened with high voltage spikes across the switch at the turn-off instant. Thus, higher voltage-rating switches are required.. Up to now, many step-up dc-dc converters have been proposed to obtain high voltage ratios without extremely high duty cycle by using isolated transformers or coupled inductors. High step-up converter based on the Cockcroft-Walton voltage multiplier is proposed. Replacing the step-up transformer with the boost-type structure, the proposed converter provides higher voltage ratio than that of the conventional Cockcroft-Walton voltage multiplier. Thus, the proposed converter is suitable for power conversion applications where high voltage gains are desired. Moreover, the proposed converter operates in continuous conduction mode, so the switch stresses, the switching losses, and EMI noise can be reduced as well. For dc-to-ac conversion, the conventional voltage source inverter (VSI) is the most common converter topology. The instantaneous average output voltage of the VSI is always lower than the input dc voltage. For this reason, a boost dc–dc converter is needed when the required ac peak output voltage is greater than the input dc voltage. This additional dc–dc boost converter increases volume, weight, cost, and losses and decreases reliability. In a closed-loop space vector pulse width modulation (SVPWM) and proportional integral derivative (PID) control method with real-time waveform feedback is presented

2. CONFIGURATION OF HIGH STEP UP DC TO DC CONVERTER

In generally to get high dc output voltage we are using voltage multipliers without using step-up transformer we can increase the size, cost and high ripples are present in output voltage and current. Cockcroft–Walton voltage multiplier (CWVM), which is an electronic circuit it generates a high DC voltage from a level input voltage AC or pulsing DC. Cockcroft-Walton voltage multiplier (CWVM) circuits are still used in particle accelerators, and also in many electronic devices where high voltages require. The Applications are x-ray machines, television, and photocopiers. It is made up of ladder network of capacitors and diodes to generate high DC voltages. Here we are using only capacitors and diodes, these voltage multipliers can step up relatively low voltages to extremely high voltage, while at the same time lighter and cheaper than using step-up transformers. The biggest advantage of such circuits is that the voltage across each stage of the cascade is equal to only twice the peak input voltage in a half wave rectifier. It has the advantage of requiring relatively low cost components and easy to insulate.

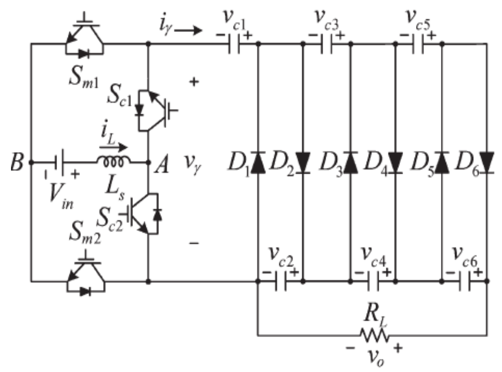

Fig 2. Converter Diagram

In this paper, proposed converter supplied by a low-level dc source, such as battery, PV module, or fuel cells. The proposed converter (Cockcroft–Walton (CW) generator, or multiplier) consists of one inductor Ls(boost inductor), four switches (Sm1, Sm2, Sc1, and Sc2) the rating of all switches are same as well as voltage stress across each switches are same, and one n-stage CW voltage multiplier The four switches are divided into two groups Sm1 (Sc1) and Sm2(Sc2) which operate in complementary mode, and they are operating under two different frequencies of Sm1 and Sc1 are defined as fsm , and fsc, respectively. For convenience, fsm is denoted as modulation frequency and fsc is denoted as alternating frequency. The both fsm and fsc frequencies should be as high as possible so that we can use smaller inductor and capacitors in this circuit. In this paper, fsm (=60 kHz) is set much higher than fsc (=1 kHz), and the output voltage is regulated by controlling by the duty cycle of Sm1 and Sm2, while the output voltage ripple can be adjusted by fsc. As shown in Fig.1, the well-known CW voltage multiplier is constructed by a cascade of stages with each stage containing six capacitors (C1, C2, C3, C4, C5, C6,) and six diodes (D1, D2, D3, D4, D5, D6,). In an n-stage CW voltage multiplier, there are N (= 2n) capacitors and N diodes n=3 (3-stage).

3. CONTROL STARTEGY

Proportional Integral Derivative (PID) control logic is widely used in the process control industry. PID controllers have traditionally been chosen by control system engineers due to their flexibility and reliability. A PID controller has proportional, integral and derivative terms that can be represented in transfer function form as

Where Kp represents the proportional gain, Ki represents the integral gain, and KD represents the derivative gain, respectively.

$$K(s) = K_p + \frac{K_i}{s} + K_d s \quad \text{.....(1)}$$

By tuning these PID controller gains, the controller can provide control action designed for specific process requirements. The proportional term drives a change to the output that is proportional to the current error. This proportional term is concerned with the current state of the process variable.

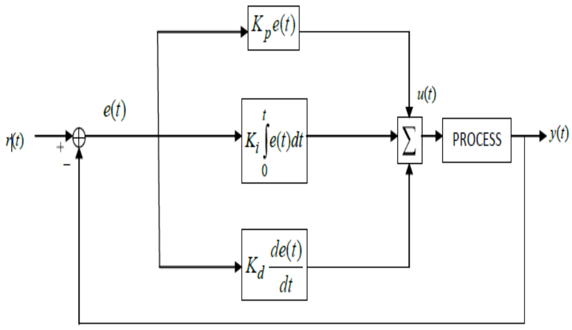

Fig 3. PID control logic

The integral term (k i) is proportional to both the magnitude of the error and the duration of the error. It (when added to the proportional term) accelerates the movement of the process towards the set point and often eliminates the residual steady-state error that may occur with a proportional only controller. The rate of change of the process error is calculated by determining the differential slope of the error over time (i.e., its first derivative with respect to time). This rate of change in the error is multiplied by the derivative gain (K d).

4. SVPM TECHNIQUE

A voltage source inverter is commonly used to supply a three-phase induction motor with variable frequency and variable voltage for variable speed applications. In SVPWM methods, a revolving reference voltage vector is provided as voltage reference instead of three phase modulating waves. The magnitude and frequency of the fundamental component in the line side are controlled by the magnitude and frequency, respectively, of the reference vector. The highest possible peak phase fundamental is very less in sine triangle PWM when compared with space vector PWM. Space Vector Modulation (SVM) Technique has become the important PWM technique for three phase Voltage Source Inverters for the control of AC Induction, Brushless DC, Switched Reluctance and Permanent Magnet Synchronous Motors.

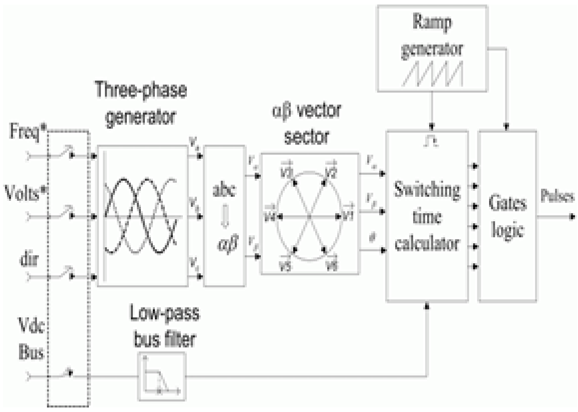

Fig 4. (a) SVPWM block diagram

When this three-phase voltage is applied to the AC machine it produces a rotating flux in the air gap of the AC machine. This rotating resultant flux can be represented as single rotating voltage vector

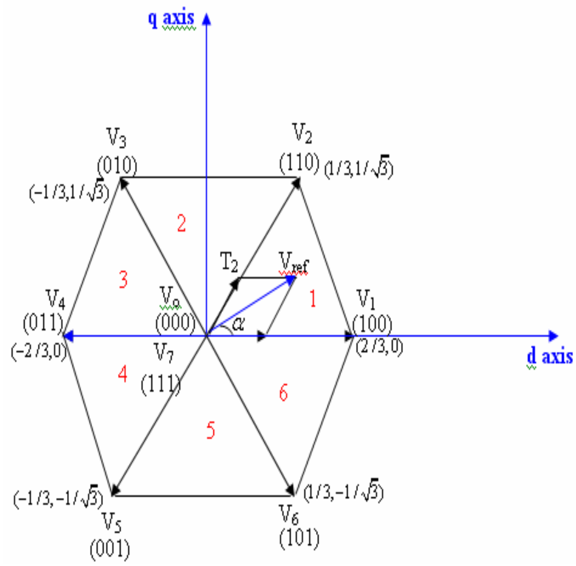

Fig 4. (b) Basic switching, vectors and sectors

Six non-zero vectors and two zero vectors are possible. Six non-zero vectors (V1-V6) shape the axes of a hexagonal as depicted in Figure-3, and supplies power to the load. The angle between any adjacent two non-zero vectors is 60 degrees. Meanwhile, two zero vectors (V0 and V7) and are at the origin and apply zero voltage to the load. The eight vectors are called the basic space vectors and are denoted by (V0, V1, V2, V3, V4, V5, V6, V7). The same transformation can be applied to the desired output voltage to get the desired reference voltage vector, Vref in the d-q plane. The objective of SVPWM technique is to approximate the reference voltage vector Vref using the eight switching patterns. One simple method of approximation is to generate the average output of the inverter in a small period T to be the same as that of Vref in the same period.

Table 1

Voltage vectors	Switching vectors			Line to neutral voltage			Line to line voltage		
	A	B	C	V_{an}	V_{bn}	V_{cn}	V_{ab}	V_{bc}	V_0
V_0	0	0	0	0	0	0	0	0	0
V_1	1	0	0	2/3	-1/3	-1/3	1	0	-1
V_2	1	1	0	1/3	1/3	-2/3	0	1	-1
V_3	0	1	0	-1/3	2/3	-1/3	-1	1	0
V_4	0	1	1	-2/3	1/3	1/3	-1	0	1
V_5	0	0	1	-1/3	1/3	2/3	0	-1	1
V_6	1	0	1	1/3	-2/3	1/3	1	-1	0
V_7	1	1	1	0	0	0	0	0	0

5. SIMULATION AND RESULTS

This paper involves simulation and results of the proposed project. The waveforms in this figure are: Fig.5.(a) simulation diagram of converter voltage,Fig.5.(b) simulation diagram of inverter output voltage using space vector pulse width modulation (SVPWM) Fig.5.(c) simulation diagram of speed of the motor. A prototype was built to verify the validity of the converter. The system specifications and the waveform explain in detail. The operation of proposed DC-DC boost converter with Cockcroft-Walton voltage multiplier, respectively. Moreover, Matlab/Simulink is applied to simulate the mathematic model and control strategy of the proposed converter. Some selected waveforms of the proposed converter at VIN=24V, η=93.5%and VO=400V for both simulation and experiment. The upper part of the switching signals having four switches, in which Sc1 and Sc2 are operated at fsc, and Sm1 and Sm2 are operated at fsm. Moreover, the simulation results of the output voltage vo, the input current iL, the terminal voltage ivy and current of the CWVM in the lower with the proposed configuration, control of single-phase or PV system to three-phase inverter has been established. This paper involves simulation of basic power electronic circuits and the analysis of the current and voltage waveforms. It starts with simple circuits with a gradual increase in complexity by inclusion of new components and their subsequent effect on the current and voltage waveforms. We focus on the objective of improving the input current waveform i.e. making it sinusoidal by tuning the circuits. All the simulation work is done in MATLAB Simulink

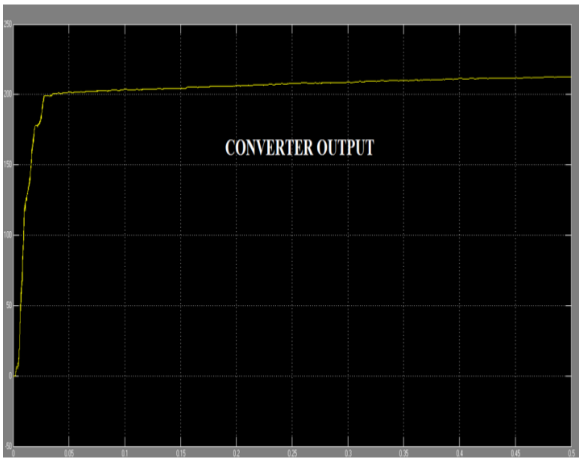

Fig 5. (a) Simulation converter output voltage

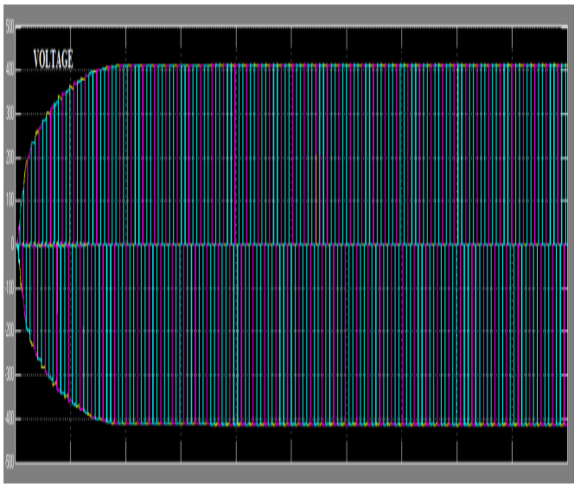

Fig 5. (b) Simulation inverter output voltage

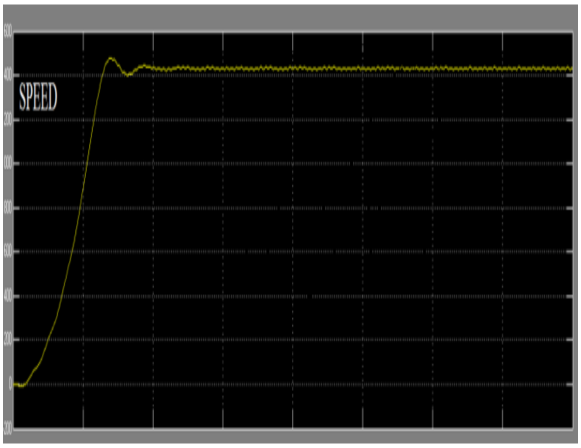

Fig 5. (c) Simulation speed output of induction motor

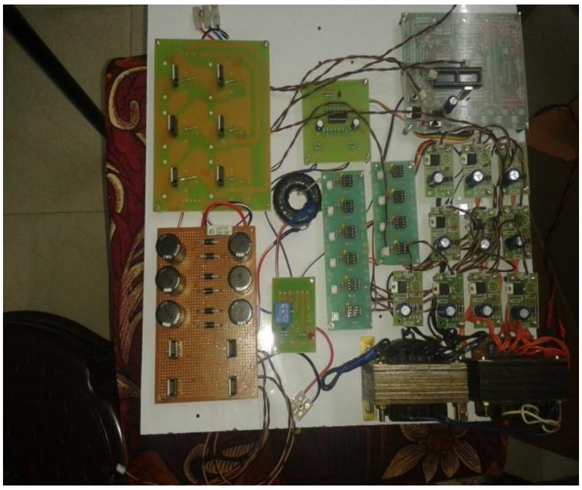

Fig 6. Hardware snapshot

6. EXPERIMENTAL RESULTS

In order to verify the performance of the proposed Cockcroft-Walton Voltage Multiplier (CWVM) compare to other converter. Here we are Using only capacitors and diodes, these voltage multipliers can step up relatively low voltages to extremely high voltage, while at the same time lighter and cheaper than using step-up transformers. The biggest advantage of such circuits is that the voltage across each stage of the cascade is equal to only twice the peak input voltage in a half wave rectifier. It has the advantage of requiring relatively low cost components and easy to insulate. Possibility of taking output from any stage, like a multi-tapped transformer. The control strategy employs two independent frequencies, one operates at high frequency to minimize the size of the inductor and other one operates at relatively low frequency to the desired output voltage ripple .Then the output of the converter is fed to the voltage source inverter. The triggering pulse to the inverter is given using space vector pulse width modulation (SVPWM). It gives us a desired output voltage gain compared to other techniques. The output voltage of the three phase inverter is sufficient to drive a three phase induction motor with voltage, current and speed. Fig 6 shows the overall circuit diagram of the proposed system.

7. CONCLUSION

This paper has presented the high efficiency and high output voltage for a three phase induction motor. The two input supplies distributed system and the PV system are given to the proposed system by using an relay. The cockcraft-walton voltage multiplier (CWVM) used in this proposed paper is to cascade the input DC voltage to high step up DC voltage in range of 200V. The input DC voltage supply is 24V. This paper highlights the advances of the CWVM by reducing leakage current, voltage ripple, switching stress in efficient way. The PID controller used to generate the error signal to produce required pulse enough to drive a converter. The output of the converter is fed to the voltage source inverter (VSI) and is triggered using space vector pulse width modulation (SVPWM). This technique gives a high voltage gain of three phase voltage 410V from the distributed system (Single phase supply) and PV system. The three phase induction motor runs at the desired speed of 1400 rpm.

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