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REDUCTION OF COMMON MODE VOLTAGE IN THREE PHASE GRID CONNECTED CONVERTERS THROUGH NOVEL PWM TECHNIQUES

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Abstract- ***High Common-mode voltage (CMV) creates many negative effects in an AC motor. CMV that has high dv/dt causes high common mode currents which in turn create problems in an inverter driven motor system. This has increased the necessity of mitigating the CMV. Photo Voltaic (PV) systems have become very popular in the recent times and normally we use a three phase VSI in PV applications. The conventional PWM methods such as Space Vector PWM (SVPWM) and Discontinuous PWM (DPWM) if used for the controller of inverter in PV applications will induce a common mode voltage. In order to mitigate the problems associated with CMV in PV inverter applications new Reduced Common Voltage PWM (RCMV-PWM) methods such as Active zero state PWM (AZSPWM), Remote state PWM (RSPWM) and Near state PWM (NSPWM) are proposed in this work. Here we discuss about AZSPWM and NSPWM. We compare them with conventional PWM methods. The effectiveness of the proposed scheme is verified by using MATLAB simulink software.***

Keywords- Common mode voltage, Common mode current, Photovoltaic, THD, Pulse width modulation, Three phase VSI, Matlab Simulink.

I. INTRODUCTION

Common-mode voltage is the potential difference between the ground and the neutral in an inverter driven motor system. In two-level three-phase voltage source inverter, the high common mode voltage (CMV) at output will be generated by sinusoidal pulse width modulation (SPWM) switching control strategy. The CMV of the inverter can stimulate both the distributed and parasitic capacitances in the system to produce Common Mode currents (CMC), which leads to the electro-magnetic interference (EMI). In the three-phase inverter-driven motor system, the CM current flowing through the motor shaft forms shaft voltage and bearing currents [1]–[4]. These overloaded bearing currents speed up the aging of the motor bearings and shorten the service life of the motor.

The use of Renewable Energy Source (RES) has increased adequately because of their abundant availability and pollutant free. Photo voltaic (PV) is one among the Renewable Energy Source (RES). The main advantage of using PV is global warming issues are taken care, conversion efficiency is improved and many more factors are improved .Weight and size are some of the factors involved for the installation of PV cells. Now-a-days Transformer less PV systems are in use. With the use of Transformer less PV systems there will be no isolation between source and ground. Due to this leakage currents are formed which in turn leads to Common Mode Currents (CMC). We can mitigate CMV by using different PWM techniques. In proposed topology we are using PV with transformer less grid connected converter. Here we can mitigate CMV by using new Reduced Common Mode Voltage PWM methods.

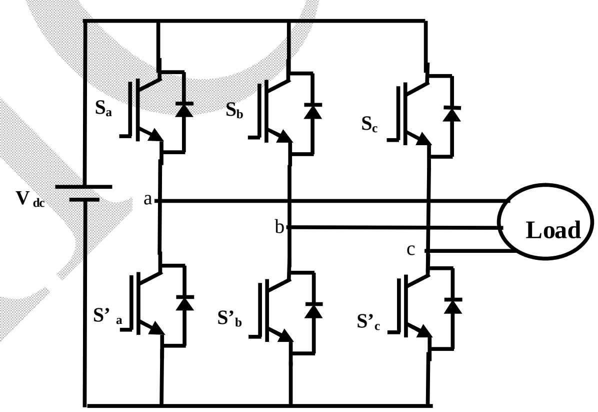

Fig : Conventional two-level inverter

Additional active filters [4]-[8] when added to the system can suppress the CMV of the inverter but they can create the problem of frequency interference, system installation difficulties and also increase in the cost because of the usage of additional complicated hardware. So to reduce CMV, the application of modified control patterns without any additional circuits is more economical and convenient than introduction other hardware for reduction of CMV in an inverter. The modulation techniques plays major role in reducing CMV.

Now-a-days in order to reduce CMV, most of the control patterns are focused on space-vector modulation (SVM) technique. But the drawback of this method is that it requires complex calculations and tables to synthesis output voltage. The change of

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control strategy has been made for mitigating Large Motor Drives: As the name indicates they are mainly used for high power loads e.g. pumps in the petrochemical industry, fans in cement industry, traction in transportation industry, steel rolling mills in cement industry, blowers, compressors and conveyors, downhill etc.

II. PROPOSED TOPOLOGY

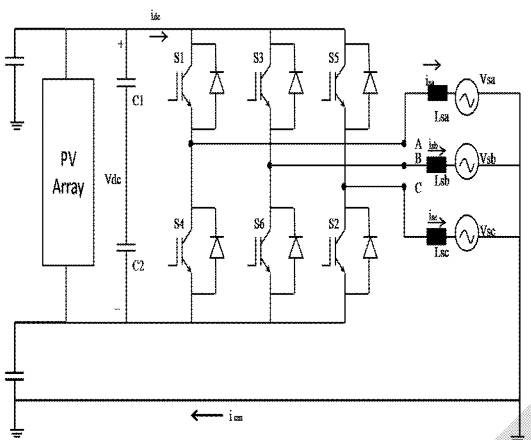

Fig 2 : Transformer less grid connected PV systems

For three phase systems we get constant AC power on the output side. Size and weight are increasing for line frequency Transformers. We can decrease efficiency by using high frequency Transformers and the system becomes complex. If we use transformers it is very costly. So we are going for Transformer less Grid connected converters. We can obtain best efficiency and cost is reduced. In this system we use PV panel. This PV output is connected to the Inverter. In this Inverter by using electronic devices and the switching operation leakage currents are occurring. To avoid leakage currents we connect stray capacitance between metal of PV panel and ground. Here considering value of 100 Nf/KWP. Stray value depends on materials used for the PV panels and the weather conditions. Due to the switching operation of the converter and the PWM methods the stray capacitance results in Common Mode Current. Due to the lack of galvanic isolation CMC is not well managed. Based on the standard requires the CMC has to maintain without exceeding 300 mA (peak) [3].

In single phase the input is a smooth signal and the output is an pulsating AC signal. Here the power is 5kwp. Because of this we use dc capacitors. Due to this dc capacitors the life of the system is reducing. For three phase large value of dc capacitors are not needed. Around 15kwp of the total power can be increased by using low dc capacitors for three phase inverters to generate a constant AC signal. Three phase VSI'S are used to drive ac loads with high quality. In order to get high output voltages the standard method is PWM. It consists of three legs .We have two transistors for each leg.

In this paper the performance of the conventional methods such as Space Vector PWM (SVPWM) and Discontinuous PWM (DPWM) and Reduced Common Mode Voltage PWM (RCMV-PWM) methods such Active Zero State PWM (AZSPWM) and Near State PWM (NSPWM) are compared with reference to generation of common mode voltage.

III. CONVENTIONAL PWM METHODS AND RCMV-PWM METHODS

3.1 Common-mode Voltage

CMV is defined as the voltage between neutral point of the load and the system ground or it may also be defined as the voltage between neutral point of the load and the dc midpoint. The mathematical expression of the common mode voltage by considering the pole voltages of an inverter is

$$V_{com} = 1/3\,(V_{ao} + V_{bo} + V_{co}) = V_{nm}$$

Where V_{nm} is the potential difference between the neutral point of inverter and reference ground and V_{ao}, V_{bo}, V_{co} are the pole voltages of Leg A, Leg B, Leg C respectively.

Voltage source inverter (VSI) cannot provide purely sinusoidal output voltages. It has discrete output voltages synthesized from the fixed dc bus voltage V_{dc} which develops CMV and so CMV is always different depending on the inverter switch state conduction. This CMV can be reduced by controlling the output voltage of inverter.

b) Conventional Methods:
 1) SVPWM 2)DPWM
c) RCMV-PWM:
 1) AZSPWM:

AZSPWM means Active Zero State PWM. Here in AZSPWM [4] we use only active vectors to get desired voltage. In AZSPWM we use same vectors as that of SVPWM. In SVPWM we use both active vectors and zero vectors. But in AZSPWM we are not using zero vectors here we use two opposite active vectors. These active vectors choice depends on the voltage command. For every 60^0 span AZSPWM1 switches. For other AZSPWM methods non-adjacent vectors will switch across 120^0 span.

2) NSPWM: In Near State PWM (NSPWM) to match the output and reference volt-seconds a group of three active vectors are utilized [9]. Based on the voltage command a near neighbour vector is used. It switches for every 60^0. The voltage vector is divided into six segments. Between 30^0 and 90^0 , the vectors are v_1 ,v_2 and v_3.

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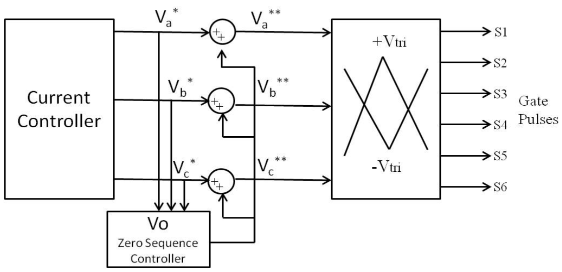

Fig 3: Control block diagram of the grid converter

AZSPWM and NSPWM methods are done by Zero sequence command and triangular carrier waves as shown in above figure. By using voltage commands v_a^*,v_b^* and v_c^* the zero sequence is produced.

1) AZSPWM1:

V_0= 1/2[max(v_a^*, v_b^*,v_c^*)+min(v_a^*,v_b^*,v_c^*)]

The SVPWM zero sequence is same as that of AZSPWM1 [11]

2) NSPWM:

By using voltage commands v_a^*,v_b^* and v_c^* the maximum magnitude is $V_{max.}$ The zero sequence is

V_0 = [sign (V_{max})].($V_{dc1/2}$) -V_{max}

The DPWM zero sequence is same as that of NSPWM [10], [12].

Here in above diagram we add zero sequence to the modified voltage commands va^*, v_b^* and v_c^* to get the original voltage commands. We compare these voltage commands with triangular carriers +V_{tri} and –V_{tri} to generate the pulses. In the voltage commands v_a^*, v_b^* and vc^* the smallest magnitude will be compared with –V_{tri} and the other two

Voltage commands are compared with +V_{tri}. From this we note that AZSPWM1 and NSPWM have same waveforms whereas NSPWM and DPWM1 have same wave form.

Table I: Parameters used

AC utility	220,V_{rms}(line to line),60HZ
AC side inductor	L_{sa}, L_{sb}, L_{sc} =5Mh
DC bus voltage	V_{dc} =370V
DC bus capacitor	1000μF
Load	1KW
Stray capacitance	C_{stray} =0.1μF

Table II: Measurment of PWM methods

	SVPWM	***AZSPWM1***	***DPWM1***	***NSPWM***
Carrier frequency in HZ	10K	1OK	15K	15K
CMC (A) RMS	2.95	0.77	0.99	0.37
Phase current (A) RMS	3.4	3.0	2.8	3.0
Phase current THD (%)	20.8	4.6	4.1	4.2
CMV	14.55	13.5	9.14	8.44

IV. MATLAB RESULTS

The above figure shows the control block diagram of the Grid converter .Here we generate voltage commands va^*,v_b^* and v_c^* based on the power flow of the converter, ac grid voltage and phase current at unity power factor. Between the positive rail and the ground a stray capacitance 0.1μF is connected and another 0.1μF is connected between ground and negative rail.

Here we have four modulation techniques SVPWM, AZSPWM1, DPWM1 and NSPWM are done by using MATLAB. The frequency of the carrier triangular wave for both SVPWM and AZSPWM1 is taken as 10KHZ. The frequency of carrier triangular wave for DPWM1 and NSPWM is taken as 15KHZ. For all these four modulation techniques the converter has same number of switching's

The common mode noise is worst in SVPWM. Here the common mode current is severe due to the usage of zero vectors. The value of RMS i_{cm} is 2.95(A). In AZSPWM1 we won't use zero vectors, here we use two opposite triangular waves. Due to the elimination of zero vectors the CMC reduces to 0.77(A).

In DPWM1 also we use zero vectors. The RMS value of the CMC i_{cm} is 0.99(A) for DPWM1. In NSPWM we don't use zero vectors, here we use two opposite triangular waves. Here the RMS value of CMC i_{cm} is 0.37(A). For SVPWM and AZSPWM1 the Common Mode Voltage changes six times whereas for DPWM1 and NSPWM the Common Mode Voltage changes four times per PWM cycle. The harmonic spectrums of the CMV for four modulation techniques are shown in above figures. For PV applications the frequency of the zero sequence circuit is low. DPWM1 and SVPWM have low ripple current. NSPWM also

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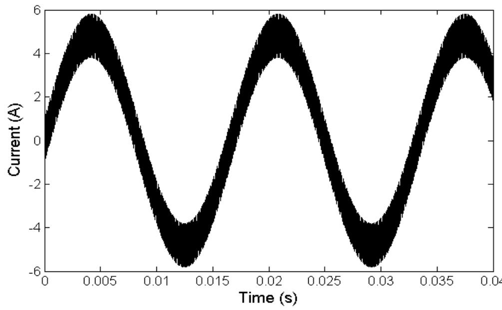
has low ripple current at high modulation index. At THD all these four methods achieves satisfactory output current.



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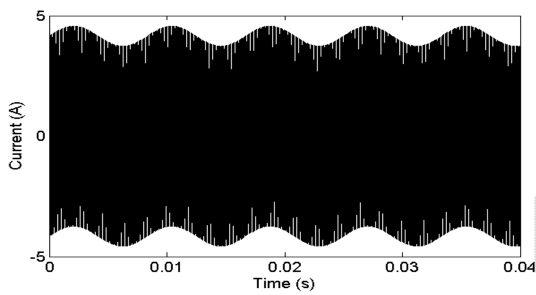

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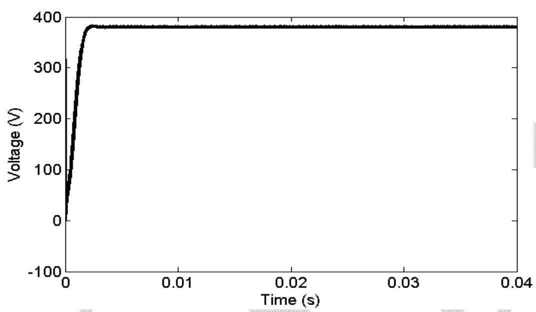

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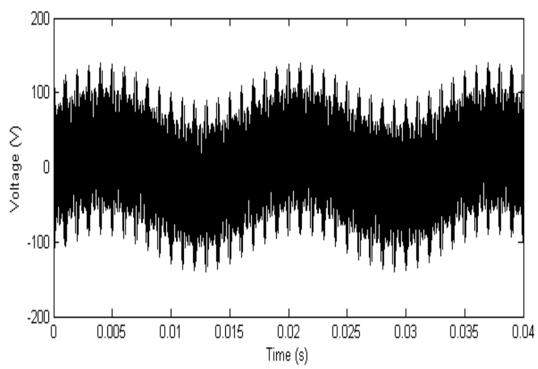

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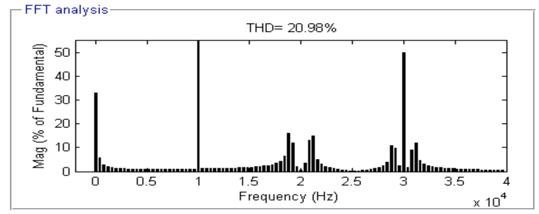
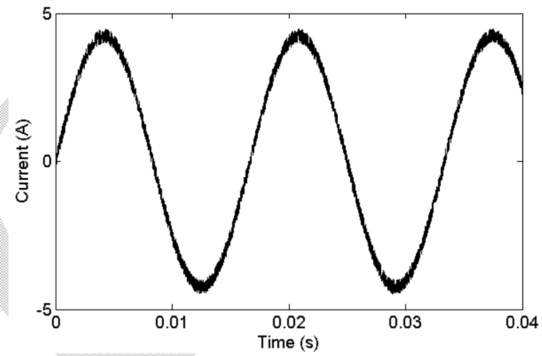


(e)

Fig (4) :SVPWM at 10KHZ (a) phase current (b) CMC (c) Voltage (d) CMV (e)THD



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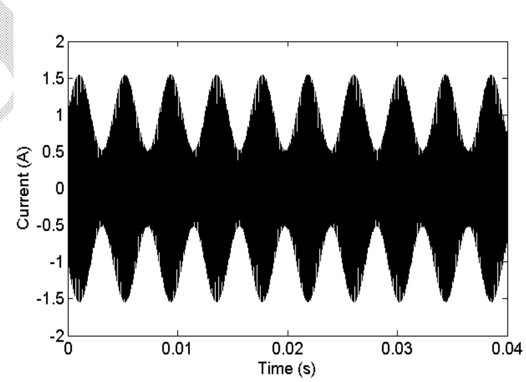

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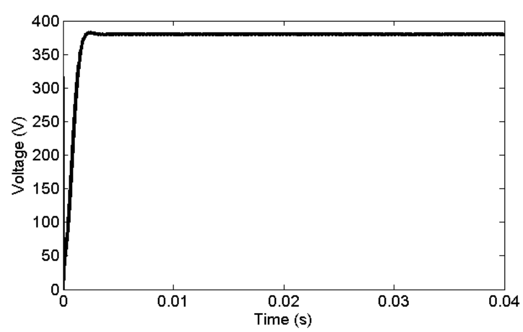

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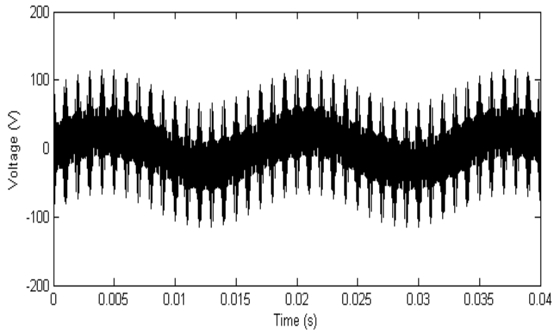

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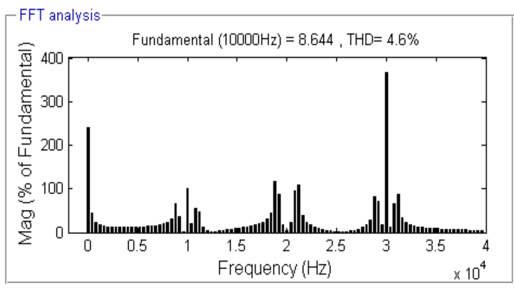
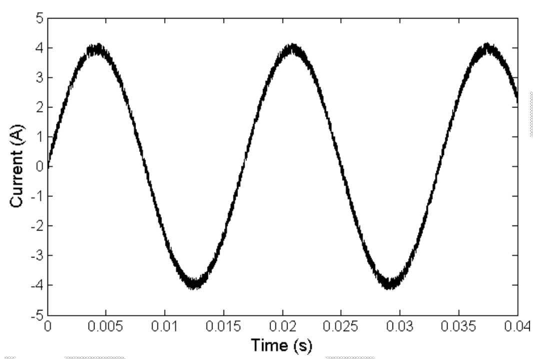


(e)

Fig (5) : AZSPWM at 10KHZ (a) phase current (b)CMC (c) voltage (d) CMV (e)THD



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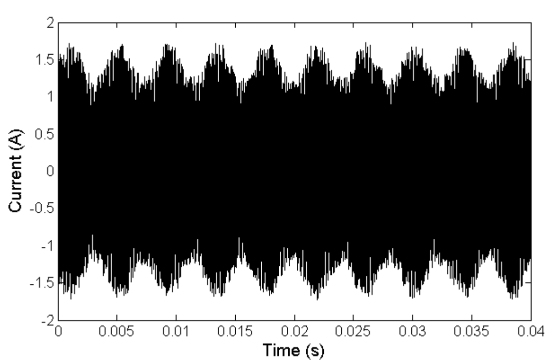

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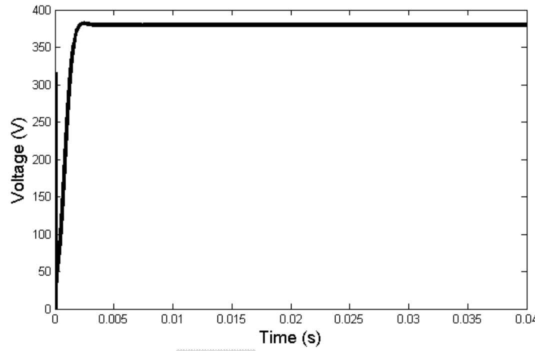

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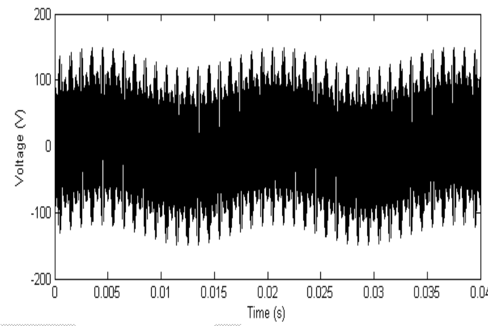

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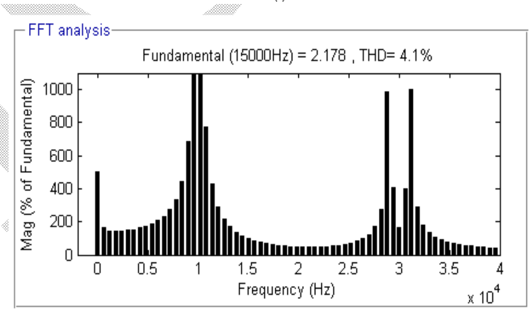
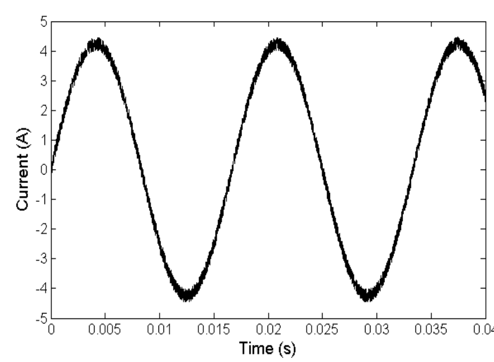


(e)

Fig 6 : DPWM1 at 15KHZ (a) phase current (b)CMC (c) voltage (d) CMV (e)THD



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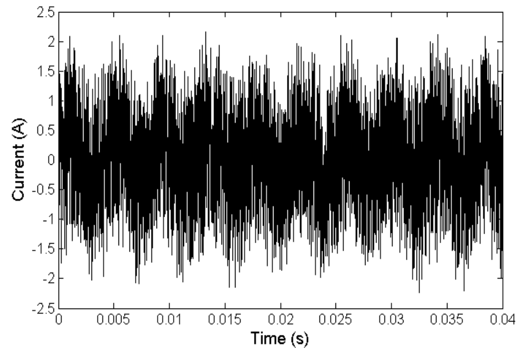

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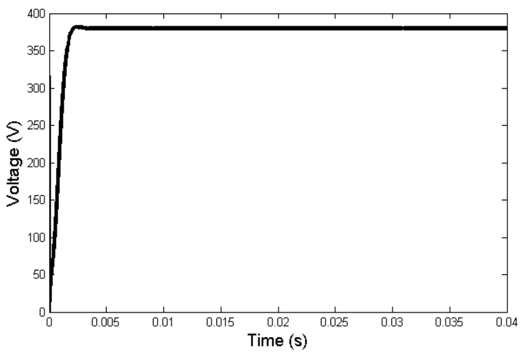

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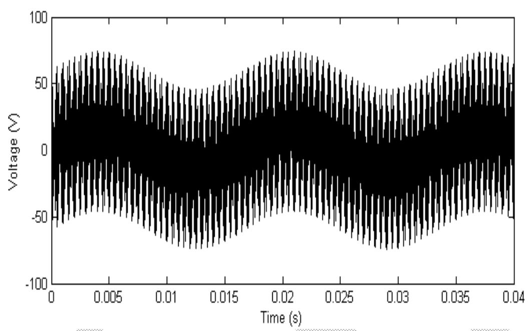

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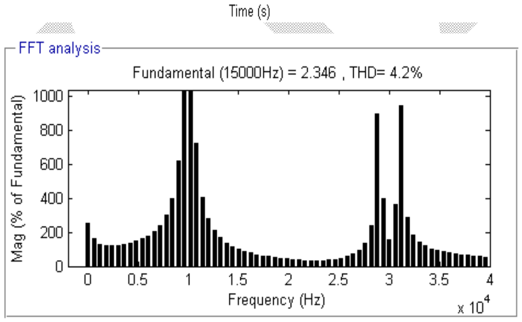

(e)

Fig 7:NSPWM at 15KHZ (a) phase current (b)CMC (c) voltage (d) CMV (e)THD

The CMC is dependent on dv/dt for motor drive applications and sometimes depends on magnitude and wave shape. Due to the large value of capacitance, the frequency will be low in PV applications. To determine RMS and CMC peak, CMV plays important role. CMV with low magnitude and RMS will be favourable. In case of dc bus, NSPWM the best method for Grid Connected PV systems. The CMV of the proposed scheme i.e. RCMV-PWM is reduced compared with conventional PWM methods.

V. CONCLUSIONS

In this paper, Transformer less Grid connected PV system has been presented which has advantage in reducing Common Mode Voltage. This proposed method is very efficient compared to conventional PWM methods. This helps in improving life span of the system. The advantage of this method is that it eliminates the peaks of the CMV and the magnitude is reduced. In RCMV-PWM methods we get low RMS value and low CMV compared to conventional PWM methods. In all these four techniques NSPWM is the best method and favourable due to its low CMV magnitude and low RMS. Further AZSPWM and NSPWM is used for Multi level Inverters.

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