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## An Intelligent Grid-Tied PV System with Dual-Charge Pump Circuits for Single-Phase Transformerless Inverters

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Abstract: Using a single-phase solar inverter without a transformer, we design a grid-connected photovoltaic system in this article. In order to stop the flow of water, we are creating a new topology that uses the electric pump concept. For control in this study, a fuzzy logic controller was employed. This paper describes a new transformer-less inverter that uses pulse width modulation

Keyword: Circuit charge by pumping (CPC), dual pumping system, transformer-less inverter.

## I. INTRODUCTION

In the past twenty years, photovoltaic systems have become more and more common. However, they, are noisy, emit no pollutants or pollution, and need maintenance. On the other hand, the photovoltaic system will produce a form of current that will damage the system's operation and assure safety.

As a result, removing the transformer helps the system function more effectively overall and is smaller and lighter. This paper describes a new transformer-less inverter that uses pulse width modulation (SPWM) to reduce the current flow in the photovoltaic grid and is based on the idea of electric power charging.



Fig 1.1 Solar, wind, and bio-power data of some biggest nations of the

Three-quarters of all global output is produced in Chine. China is the biggest renewable energy source are produced according to fig 1.1. One of the reasons of that is non-polluting.it is no harmful for nature. On the other hand, it reduce the loss of the current.



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This data shows how energy sources have become used more or more by early. This graph is increasing year by year. The price of solar energy is steadily declining.



Fig 1.3 Illustration of loss of current in dc to ac inverter

The above fig 1.3 shows that the input is connected to the photovoltaic system to the inverter and the output is connected to the grid. L1 and L2 filter. Ig is the loss of current.  $V_{CM}$  is the voltage across the system and the base.

$$V_{cm} = \frac{V_{An} + V_{Bn}}{2} + \frac{(V_{An} - V_{Bn})(L_1 - L_2)}{2(L_1 + L_2)}$$
(1)

$$V_{cm} = \frac{V_{An} + V_{Bn}}{2} = Constant$$
(2)

$$V_{cm} = \frac{V_{An} + V_{Bn}}{2} + \frac{(V_{An} - V_{Bn})}{2} = Constant (L_1 = 0)$$
  
Then,  
$$V_{cm} = \frac{V_{An} + V_{Bn}}{2} - \frac{(V_{An} - V_{Bn})}{2} = Constant (L_1 = 0) (3)$$



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This inverter is based on CPC (Charge Pump Circuit). The suggested configuration uses just 4 energy switches, cutting the price of electronic components and boosting the electrical performance through a 3-step voltage that decreases the current stream amplification. The research presented here proposes an innovative transformerless inverter designed around the CPC theory, which reduces the current loss of solar energy connected to the grid utilizing a sinusoidal pulse width modulation (SPWM) strategy.

#### **II. TOPOLOGY AND MODULATION**

## A. CPC Structure

The CPC is the pump circuit. There is 2 diode, 2 capacitors interconnected to each other. Current flows through the positive to negative points.

 $V cm = -V dc + V cut - in - D_1 + V cut - in - D_2 (4)$ 





## B. Methodology

There is 4 switch circuit are represented. If  $D_1$  is forward then  $C_2$  is conduct and  $D_2$  is reverse2.d then  $C_1$  charges by  $D_1$ .



Fig 2.3 Transformerless inverter proposed



Fig 2.4 Switching pattern energy

Energy is flow from the inverter to the grid.









Fig 2.5 different inverter structure



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iCapacitors = 
$$Ce1 V C1 - VC 2$$
 (6)  
 $\tau C_2$ 

$$\tau C 2 = \text{Re } 1Ce1$$

Equation (6) and (5) there is very miner difference between them

(5)

(7)

(8)

#### **III. ANALYSIS OF TOPOLOGY**



(a) Zero mode

dvaiff,1	Vdiff,	$1 - R_{s3}i_g$	
dt	(Rel	$+R_{s3})C_{e1}$	
dvaiff, 2	Ipv	$V$ diff, 1 – $R_{s3}i_g$	
dt	$C_B$	$\frac{1}{(\mathrm{Re}_1+R_{s3})C_1}$	



$$\frac{dv_{diff,1}}{dt} = \frac{R_{cb}I_{PV} + dv_{diff,2}}{(R_{cb} + R_{c}_{2})C_{1}} + \frac{i_{g}}{C_{2}}$$
(9) 
$$\frac{dv_{diff,2}}{dt} = \frac{I_{PV}}{C_{B}} + \frac{R_{cb}I_{PV} - v_{diff,1}}{R_{c}_{2}C_{c2}}$$
(10) 
$$R_{c}_{2} = R_{D2} + R_{s1} + R_{c1} + R_{cB}, C_{c2} = \frac{C_{1}C_{B}}{C_{1} + C_{B}}$$
(11)

Equation (11) is shows that the mathematical representation of the resistance and capacitor of the system

$$\frac{dv_{aff,1}}{dt} = (1+s(t))\frac{v_{aff,1} - R_{c}s_{lg}}{(R_{c1} + R_{c})C_{c1}} - s(t)(\frac{R_{cB}H_{PV} + v_{aff,2}}{(R_{cB} + R_{c})C_{1}} + i_{g}C_{2})\frac{dv_{aff,2}}{dt} = (1+s(t))(\frac{H_{PV}}{C_{B}} - \frac{v_{aff,1} - R_{c}s_{lg}}{(R_{c1} + R_{c})C_{1}}) - s(t)(\frac{H_{PV}}{C_{B}} + \frac{R_{cd}I_{PV} + v_{aff,2}}{(R_{c2} + C_{c2})})$$
(12)

 $s(t) = \begin{cases} 1 \text{ when the circuit is at positive state} \\ 0 \text{ when the circuit is at zero state} \\ -1 \text{ when the circuit is at negative state} \end{cases}$ 



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$$\langle i_{\rm S1, max} \rangle T = \frac{1}{2} \left( \frac{C_1}{C_1 + C_2} + 1 \right) \left( \frac{M \, \text{Im}}{1 - M} + \frac{T_s}{R_c \, 1C_{\rm Fl}} \frac{1 - M}{2} \right)$$
(15)  
$$\langle i_{\rm S3, max} \rangle T = \frac{1}{2} \left( \frac{C_1}{C_1 + C_B} + 1 \right) \left( \frac{M \, \text{Im}}{1 - M} + \frac{T_s}{R_c \, 2C_{\rm F2}} \frac{1 - M}{2} \right)$$
(16)

$$ic = C \frac{\Delta v_c}{\Delta t}$$
(17)

$$C_{1} \text{ or } \mathbf{B} = \frac{Ic_{1} \text{ or } \mathbf{B} \left( \max \right)}{\bigwedge \left( V_{r} V_{n} \right) f}$$
(18)

MOSFET: $v_{Ds}(t) = i(t) R_{DS}$	(19)

Diode:  $v_{AK}(t) = V_F + i(t) R_{AK}$  (20)

Where,

 $V_{DS}$  = drain source voltage,  $R_{DS}$  = drain source resistance,

 $V_{AK}$  = anode cathode voltage,

 $V_F = equivalent voltage$ 

$$\frac{1}{\pi} \pi$$

$$P_{MOSFET\_Cond} = \int v_{DS}(t)i(t)d_{MOSFET}(t)d\omega t (21)$$

$$\pi_{0}$$

$$P_{Diode\_Cond} = \frac{1}{\pi} \int_{0}^{\pi} v_{x}i(t)d_{Diodes}(t)d\omega t$$

$$= \frac{1}{\pi} \int_{0}^{\pi} v_{x}i(t)R_{x}i(t)d_{Diodes}(t)d\omega t (22)$$

 $P_{MOSFET\_SW} = f_{SW}E_{OSS}V_F$  (23)

$$P_{Total} sw = 4 f_{sw} E_{oss} V_F = 3.46W$$
(24)

$$P_{CAP\_Cond\_1} = \frac{2(R_{C1} + R_{CB})}{\pi} \int_{0}^{\pi} d_{c}(t) i_{s1}^{2}(t) d\omega t \quad (25)$$
$$P_{CAP\_Cond\_2} = \frac{2(R_{C1} + R_{C2})}{\pi} \int_{0}^{\pi} d_{c}(t) i_{s3}^{2}(t) d\omega t \quad (26)$$

It shows that loses of the capacitor.

$$G_{PR(s)} = K_p + \frac{2K_r}{s^2 + \omega^2}$$
(27)  
$$P = \frac{V_{ga}i_{ga} + V_{g\beta}i_{g\beta}}{2}, Q = \frac{V_{ga}i_{ga} - V_{g\beta}i_{g\beta}}{2}$$
(28)



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Equation (28) shows the value of the current and voltage components of the gird.

$$L_{f} = \frac{(v_{dc} - v_{An}) (M \sin \omega t)}{f_{SW\Delta iL}}$$

$$V_{An} = MV_{dc} \sin \omega t \qquad (31)$$

$$L_{f} = \frac{(v_{d}) (RF)}{f_{SW\Delta iL}}$$
(32)

Equation 30,31 and 32 are observed and put value  $R_{\rm f}$  form equation 33

$$RF = M\sin\omega t - M^2\sin^2\omega t \qquad (33)$$

 $C_{f}$  represents the f is frequency, V if the voltage of the system and P is the power. Equation (35) shows that the grid and inverter inductor are directly proportional to each other but the attenuation constant are present in between these two inductor.

$C_{F,\max} = \frac{0.05P_n}{2\pi f V_{rms}^2}$	(34)
$L_g = rL_f$	(35)

#### **IV. FUZZY LOGIC CONTROLLER**

Fuzzy controller are basically used for the numerical value converted into logical value. This controller gives logical expression. It is true or false and 1 or 0. There are some basic rule present in this controller. There are three type of this controller. That is shown in fig 4.1



Fig 4.1 FLC

e è	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	P5	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

Fig 4.2 Rules



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There is some rules shown in fig 4.2, which is the seven set of fuzzy input and fuzzy output, the "min" operation and each set are used as a triangular form.

$$E(k) = \frac{P \text{ ph } (k) - P \text{ ph } (k-1)}{V \text{ ph } (k) - V \text{ ph } (k-1)}$$
(36)  
$$CE(k) = E(k) - E(k-1)$$
(37)

(38)

 $u = -[\alpha_{\mathrm{E}} = (1-\alpha) * \mathrm{C}]$ 









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## V. SIMULATION RESULTS

#### Table IV Parametersthe 500 W Prototype

Parameter	Value	Parameter	Value	
Power rating (P)	500 W	Capacitance $(C_1)$	220 µF, 500 V	
Input voltage $(V_{dc})$	400V	Capacitance $(C_2)$	330 µF, 500 V	
Output voltage (v <sub>Bn</sub> )	220 V (RMS)	$\hat{L}$ filter $(L_f)$	4 mH	
Input capacitor $(C_B)$	470 µF, 500 V	$C$ filter ( $C_f$ )	$2.2 \mu\text{F}$	
Power switches $(S_1 - S_4)$	C2M0080120D, SiC MOSFET	$L_g$	2 mH	
Diodes $(D_1, D_2)$	C3D10060A Schottky Diode	Switching frequency $(f_s)$	24 kHz	





#### Fig 5.1 MATLAB Model







There is result shows that fig 5.2 and Fig 5.3, it conduct sinusoidal waves and low disturbances.



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#### VI. IMPLEMENTED WORK



Fig 6.1 MATLAB inverter model

## This model are built in MATLAB 2016.

- Parameters: For PV array:
- Power: 315W
- Temperature Range:  $21 36^{\circ}$  C
- Solar Panel : 15

#### For Inverter

- maximum input Power: 5.8KW
- maximum input Voltage: 600V
- maximum efficiency: 96.7 %

#### VII.CONCLUSION

This work is based on the CPC principle. To create the transformer-free inverter to use in solar. With the goal of getting higher reliability, manage algorithms. Fuzzy logic controllers are perfect for this theory. It gets better results for the system to support decisions for future purposes.

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