A Study on Synchronized AC Source Voltage Regulator of Voltage Fed Inverter using a Photovoltatic Effect

* Lak-Hoon Hwang * Chun-Sang Lee * Jong-Lae Kim * Byong-Gon Jang
* School of Electrical and Electronic Eng., Semyung University san 21-1, sinwol-dong, jecheon, chungbuk, 390-711, korea Tel. (0443)649-1302, 645-1125~9,

Abstract - In this paper, we composed of utility interactive pv generation system of voltage source inverter, and represented uninterruptible power supply (UPS) equipment maintaining constant output voltage, using a pulse width modulation(PWM) voltage fed inverter, as power source disconnection, voltage variation and output current variation with load variation.

This system is driven by being synchronized voltage fed inverter and AC source, and in the steady state of power source charge battery connected to dc side with solar cell using a photovoltaic (PV) that it was so called constant voltage charge.

In addition, better output waveform was generated because of PWM method, and it was proved to test by experiment maintained constant output voltage regardless of AC source disconnection, load variation, and voltage variation of AC power source.

I. Introduction

The present, system of DC generation began observed to method of development of new energy source instead of patroleum in main energy source using sun energy, wind-power and so on. [1]~[10]

There system have many good that it is not necessary environment pollutin, deffusion of fuel and so on.

But, these systems have bad that it can't continous generation to single.

So it is necessary that these systems save to battery or interconnection to utility line.

D/A converter is required because load was mostly AC load.

In case of operation of interconnection utility line, it is necessary that supply voltage and current of sin-wave have unit power factor to line.

In this systems, must be always to control pursue after mximum power, it because of the output propertion of solar cell is influenced to fulx of insoulation.

Also, PWM require modulation of safe when distortion component included in line source vlotage waveforms of synchronous signal

Because of exit time difference between sampling point and carrier wave, it is required method of compensation. [1]~[17]

In this paper experimented for voltage regulation and power supply equipment to preparation of power cut off using property of AC source current became sin-wave. This system scheme PWM voltage fed inverter

There was only completed one inverter executed function of power supplied of constant voltage to load and charge to DC side as control of phase of AC voltage,

Ⅱ. Voltage fed inverter of system interconnertion

1. system summarization

1-1 power convertion and propertion of harmonics

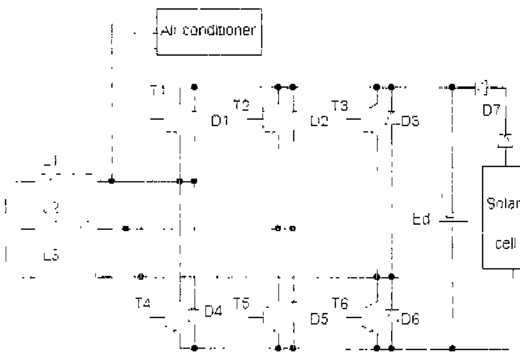

Fig.1. Power conversion system

System of voltage regulator consist of two voltage source and reactance X_L, solar cell device and so on

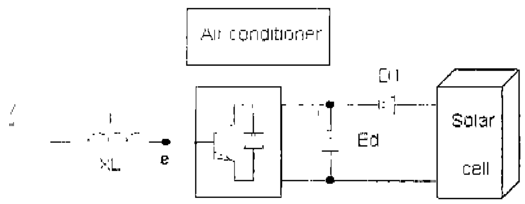

Fig.2 Equivalent circuit

If we make circuit Equation for Fig.2, It is described the following as Equation (1).
Where θ is wt.

$$V-e=X_L di/d\theta \quad (1)$$

Source current is obtained as integration two side of Equation (1)

$$I=1/X_L\int(V-e)d\theta \quad (2)$$

If V is $V_p\cos\theta$, Solution of Equation (2) is indicated the following as

$$i=1/X_L\int(V_P\cos\theta-e)d\theta$$
$$=V_p/X_L\sin\theta-1/X_L\int ed\theta \quad (3)$$

Where

$V_p/X_L\sin\theta$: Fundamental wave component of source current

$1/X_L\int ed\theta$: add Fundamental wave component of AC side and the restharmonics component.

Harmonics component only consider that second term in Equation (3) because frequency of fundamental wave and source is equal.

Therefore, if we second term only expand again, we can konw that porperty of harmonics is indicated the following as

$$1/X_L\int ed\theta=1/X_L\int(e_1+e_3+e_5+\cdots)d\theta$$
$$=1/X_L\sum_{n=1}^{\infty}\int e(2n-1)\,d\theta \quad (4)$$

Where, e is AC side waveforms of voltage regulator which are PWM waveforms and it indicated the following as Equation (5)

$$e_n=e_1+e_3+e_5+e_7 \quad (5)$$

where e_n is instantaneous value of nth harmonics

In case of only considered nth harmonic coefficient of exception of fundamental wave, it indicated the following as

$$i_n=e_n/X_L\times 1/n \quad (6)$$

only, n=3, 5, 7, 9

As shown in Equation (6), relative harmonic content is reduced as increment of n

Bacuse of V was source voltage, rms value of fundamental wave for source current is expressed the following by concern of Equation (2) and (4)

$$I=(V-E)/X_L \quad (7)$$

1-2 Harmonics analysis of PWM waveform and scheme

In order to reducing harmonics component by means of application with PWM control, since it can be inverter output voltage waveforms to driver in inverter system. Fourier series of output voltage can be follows as

$$E(\theta) = \sum_{n=1}^{\infty} (b_n \sin n\theta) \qquad (8)$$

(n = 1, 5, 7, 11 • • •)

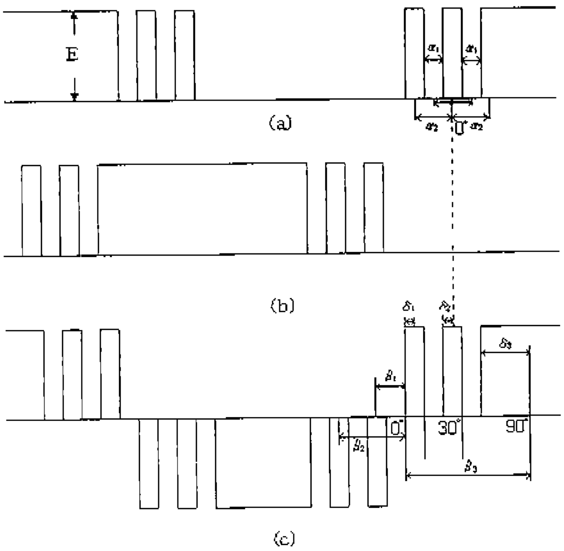

Fig.3. PWM waveforms.

(a) Transistor T1 waveform.

(b) Transistor T2 waveform.

(c) Output waveform.

Because of Voltage control is regulated of fundamental voltage in Fig.3, The Fourier series of PWM waveform is given by Equation (9)

$$V_1 = 4E/\pi \int_0^{\frac{\pi}{2}} E(\theta) \sin \theta d\theta$$

$$= 4E/\pi [\int_{\beta_1 \ \alpha_1}^{\beta_1 \ \alpha_1} \sin \theta d\theta + \int_{\beta_2 - \alpha_2}^{\beta_2 + \alpha_2} \sin \theta d\theta$$

$$+ \int_{\beta_3 - \alpha}^{\beta_3} \sin \theta d\theta]$$

$$= 4E/\pi (2 \sin \beta_1 \sin \alpha_1 + 2 \sin \beta_2 \sin \alpha_2 + 2 \sin \beta_3 \sin \alpha_3)$$

$$= 4E/\pi (K_1 \sin \alpha_1 + K_2 \sin \alpha_2 + K_3 \sin \alpha_3)$$

$$= 4E/\pi \sum_{n=1}^{3} K_n \sin \alpha_n \qquad (9)$$

The system studied is composited of two simultaneous Equations of which (10) pulse width β is fixed, and then in ratio voltage ±15% at constant of K are decided of α_1 = 15.25°, α_2= 23.3°. voltage of system is regulated to involve variable 16-step voltage, and it can of scheme in variation voltage

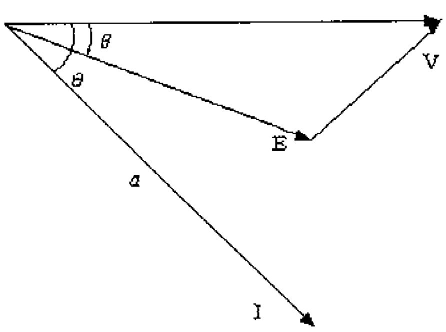

Fig.4. Vector diagram of AC side source voltage and currents.

Source voltage is indicated the following as Equation (9) when phase of power converter is α

$$P_{ac} = VI\cos\theta = VE/X_L \sin\alpha \qquad (10)$$

Also, Power of DC side is indicated the following as Equation (11)

$$P_{dc} = E_d I_d \qquad (11)$$

I_a is explained by conditions of battery if battery became charge to constant voltage in Equation (12).

Power of difference between Equation (10) and Equation (11) supply to load in Fig.1. So concern of Equation (10) and Equation (11) is obtained the following as Equation (12)

$$P_{ac} = P_L + P_{dc}$$

$$P_{dc} = P_{ac} - P_L \qquad (12)$$

P_L : power of load parallel connected to converter

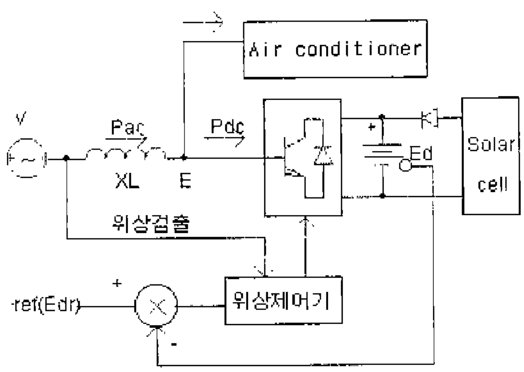

Fig.5. Control circuits.

Terminal voltage became constant voltage and power supplied to load by Equation (12) because control circuit of Fig.5 controlled constant voltage E_{α} by we determined value of α to voltage of battery continued constant voltage.

2. Scheme of total system

2-1 property of system operation

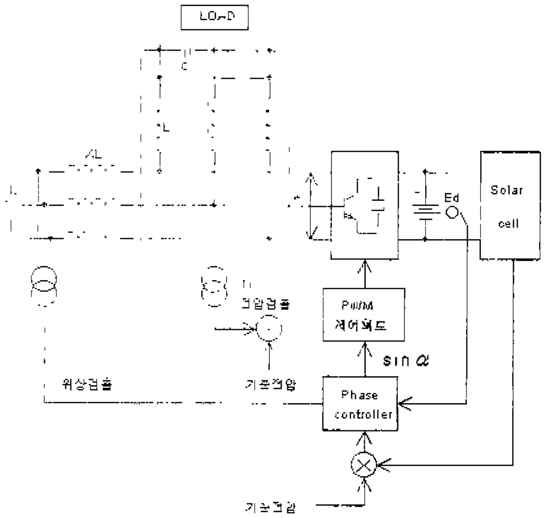

Fig.6. Main circuit system.

Fig.6 is power supply system to preparation to power cut off and voltage regulation.

This system schemed loop of charge to constant voltage to battery by control of phase and power supply in load as PWM inverter is driven by detection of voltage when power is cut off. This system use the utility line to continue power between DC source and AC load as power flow diagram in Fig.7. Output voltage of load is supplied from commercial source in operation mode of parallel and inverter is mitigated harmonics current of load, and it became constantly with battery continue constant voltage

In case of commercial source is cut off, it changed to single operation mode from parallel operation mode. Voltage fed inverter supply voltage constantly to load with changing to AC from DC source by PWM.

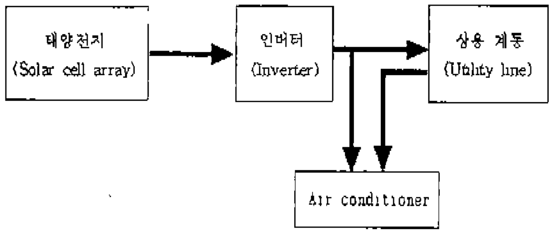

Fig.7. Power flow diagram of PV system.

This system good is not interruption of power supply because load is always connected to voltage fed inverter of output voltage is controlled constantly.

2.2 output property of solar cell

Operating point to obtain maximum power become point in voltage of two side of solar vattery times current flow to solar cell is maximum as shown in Fig.8.

Also, short current I_{sc} of solar battery vary to proportional as flux of insolation. and variation of open voltage E_{oc} is a little.

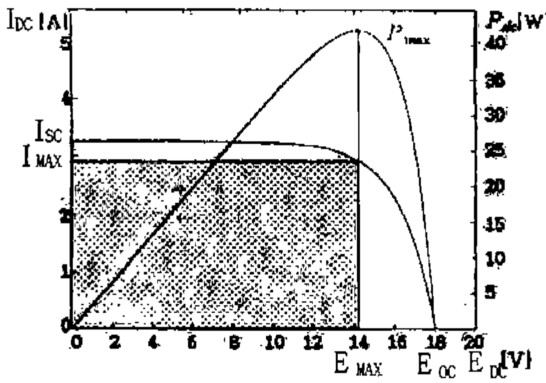

Fig.8. Output characteristics.

In generally, I_{sc} is very large when compare to I_0, and approximately I_{max} value of become proportis to to short current I_{sc} because change of values of E_{max} vary a little as flux of insolation. So, we can defind E_{max} and I_{max} using data of measurement for open voltage of solar battery and short current.

Fig.9 indicate ouppput property of solar battery as variation of flux of insolation.

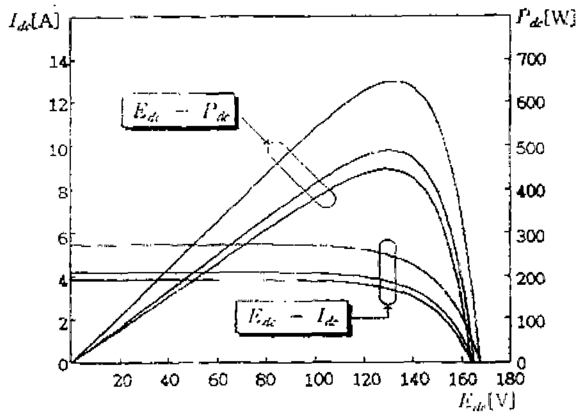

Fig.9. Output characteristics by the flux of insolation.

Ⅲ. experimentation and investigation

We expressed that load ouppput voltage was constant for variation of load, variation source and power cut off Useing power supply of V=220[V], charging voltage of E_a=120[V], maximum power of 4.3[W], open voltage of 158[V], short current of 3.32[A], reactance of X_L=50[mH], solar baterry connected to four set serial-parallel, and lamp load.

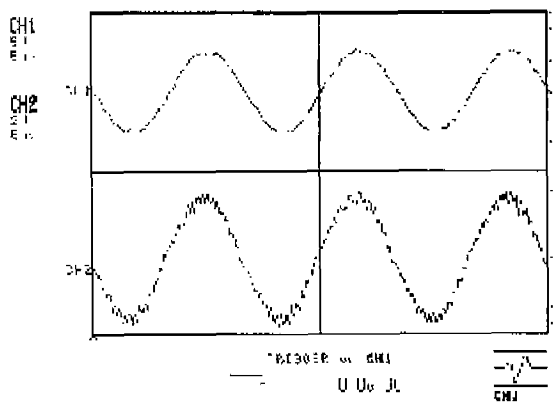

Fig.10. Utility line voltage and load current waveforms.

Fig.(10) is result of simulation for the output voltage of inverter, current waveform of load, voltage of system disconnection and current waveform.

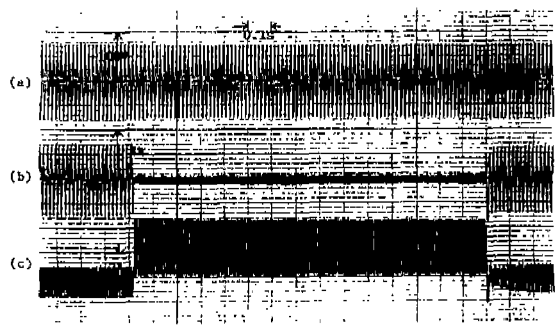

Fig.11. Disconnection of input source.
(a) Output voltage AC input power source
(b) Input current of AC
(c) Current of DC side

In Fig.11, in case of AC source cut off, we experimented for range of (a) was ±30° and waveform of (b) indicated condition of cut off while AC input voltage supplied constantly and again, waveform of (c) indicated that AC output voltage of (a) became constantly by voltage regulator discharge current of battery to repress variation of voltage.

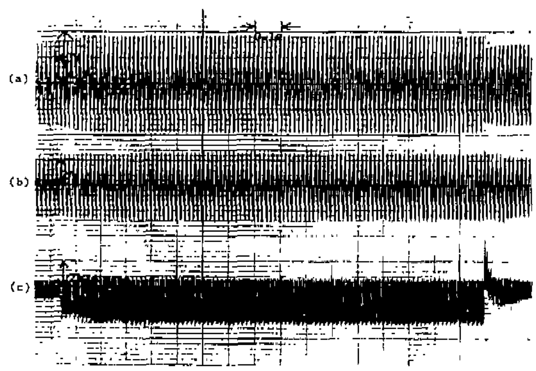

Fig.12. Case of sudden load variable.
(a) Output voltage (b) AC input current
(c) Current of DC side

In fig.12, in case of AC source continued constantly and varying load, AC input current of (b) is increased a little by angle α is varied, output waveform of (a) by constantly continued by charging of battery as shown in DC side current waveform of (c).

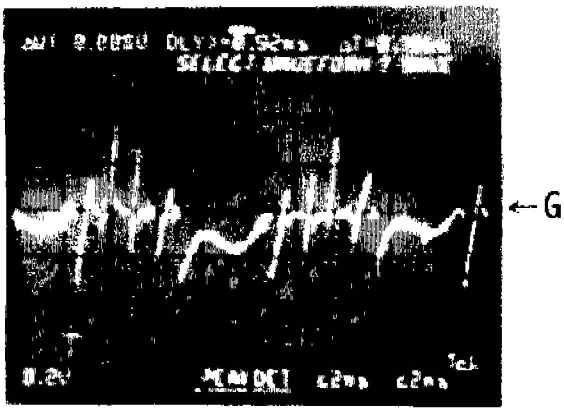

Fig.13. Charge current waveform of DC side.

Fig.13 shown charging voltage and Fig.14 shown input voltage before filtering by PWM, phase of output voltage waveform and AC sorce, Fig.15 indicated output voltage after filtering.

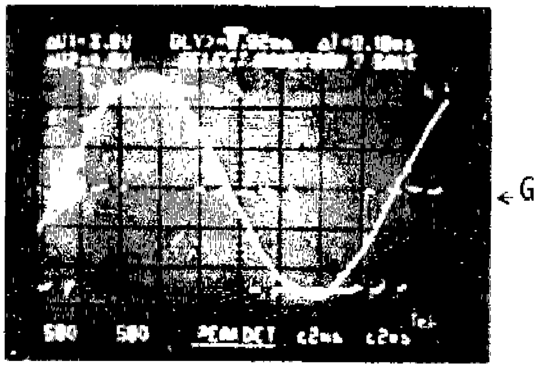

Fig.14. Phase α for input voltage waveforms and output voltage waveforms of voltage source inverter.

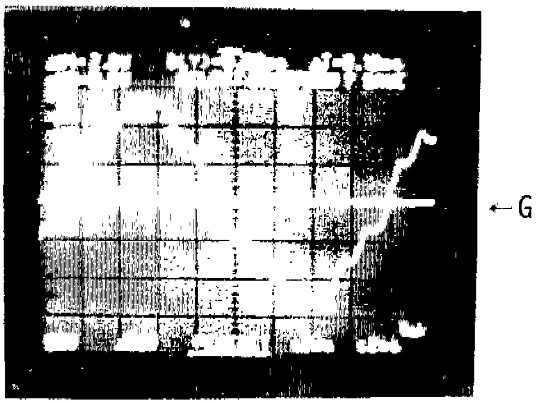

Fig.15. Waveform of output voltage.

Ⅳ.Conculution

This Paper obtained result as the following for operating ups by PWM is varied 16-step if operating synchronize commercial AC source, cut off source, in case of variation of commercial AC source and load, DC charge and so on by solar battery.

(1)control of voltage fed inverter is possible to convertor AC side control by solar battery

(2)This system continued constant voltage for variartion of load and input source voltage

(3)transient condition is a little when source cut off and DC source entered by solar battery.

(4) experimentation required scheme of AC power filter to repress detection of rms values of harmonics, because of there much variation of solar batery, we propose to subject of study that system include wind-power

(5) There is applicated to ups system by solar cell and wind development if this problem solve.

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