한국조명·전기설비학회 2004춘계학술대회 논문집(2004.5.7~8)

Inverter Air-conditioner Power System with Low Power Dissipation Type using Micro-controller

Sang-Pil Mun · Ki-Young Shu · Ju-Yong Kim · Kwang-Tae Kim*
Kyungnam Univ. · Busan College of Information technology*

Abstract

When using a conventional power factor correction circuit, a comparatively huge capacitor is used to boost-up output voltage. It has a large amount of harmonic distortion in the input current waveform. To improve the input current waveform of diode rectifiers, we propose a new operating principle for the power factor correction circuit. Due to the fact that the proposed circuit uses smaller ones and a smaller reactor, the output voltage increases and obtains higher input current waveforms. These are suitable for the harmonics guidelines. The proposed circuit is able to obtain higher power factor and efficiency. Also, it has reduced switching loss and held over-shooting by using an inverter of eliminated dead-time HPWM that has non-linear impedance circuits to make up diodes, capacitance and a reactor. We compared the conventional PWM inverter and proposed HPWM inverters and found that a high input power factor of 97[%] and an efficiency of 98[%] were also obtained.

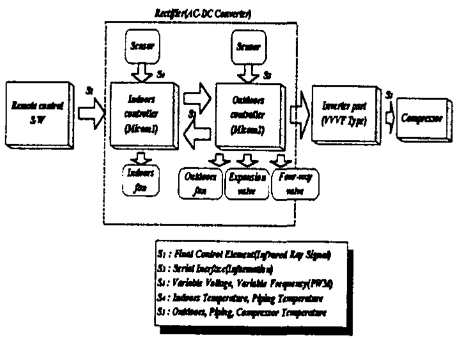
1. Introduction

As inverter systems have become increasingly popular as household electric appliances or a industrial machinery, a harmonic distortion occurs in the capacitor input type diode rectifier and is accepted by a direct current source. As a countermeasure to this, it imposes legal controls on the quantity of harmonic current.[1],[2] Recently, various methods have been studied to help rectify this problem. Among those, an excellent waveform reform measure was developed by using a self-commutation device at a several hundred watt class low power rectifier.[3] However, as the result of this technique as an inverter controlled air-conditioner is typical of direct current power, it is applied to a single phase middle-capacity rectifier and thus avoids the problems that are associated with efficiency, viability, rapidity and electro-magnetic noise. Due to these problems, a rectifier that is satisfied with the guidelines of harmonics, is developed by using a diode and passive device.[4] However, those rectifiers have some degree of insufficiency with respect to general-purpose. In this paper, the aim is to replace the conventional huge capacitor, which used power factor correction circuit, with a small capacitor. When joined with a reactor, it can improve the input current waveform and reduce rising output voltage. We will propose a number of circuits to the power factor correction circuit

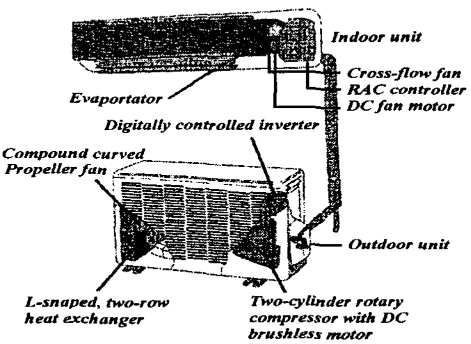
Also, we will represent the experimental result that it is satisfied with the regulation of harmonics, and projected within the parameter of those characteristics.

2. Consist system of inverter air-conditioning

The Fig. 1 is represented to block diagram and actual system of inverter air-conditioning. Fig. 2 represents a Air-conditioner power system using power factor correction circuit which is usually used in air-conditioners, and its input current and voltage waveform is shown in Fig. 3.



(a) Block diagram



(b) An actual air-condition system

Fig. 1. Block diagram of inverter air-conditioning

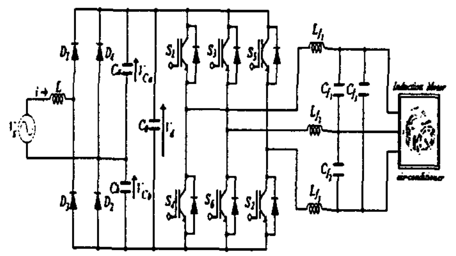


Fig. 2. Air-conditioner power system using power factor correction circuit

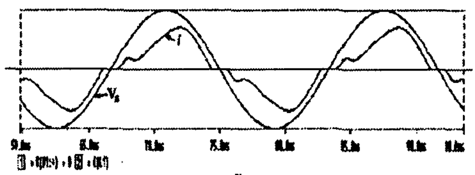


Fig. 3. Input current and voltage waveform

The configuration of this circuit has something in common with a conventional power factor correction circuit, But, the capacitor C_a and C_b have smaller capacities, and the capacitor voltage VC_a, VC_b are charged or discharged by inserting the reactor L on the input side between zero and load voltage Vd during the half cycle of the power as shown in Fig. 3.

This circuit has two resonant operation modes in a half cycle of the power source. As these two modes act as the function of time, it is difficult to analyze the harmonics component of input current using conventional analysis methods. The operation is decided by the value of input currents, L, $C_a(C_b)$. When the design of rectifier circuits using extracted parameters are used in this method, we can *obtain suitable optimal parameters in the guidelines of the* input current. In Fig. 2, if the smoothing capacitance of C_0 is larger than C_a, the 1st operation circuit is measured as an equivalent circuit and L is connected on a parallel circuit of C_a and C_b. Then, the power source voltage v is represented as an equation (1) as follows:

$$v=\sqrt{2}\,V\sin wt \tag{1}$$

Based upon the values of $VC_a(0)=0$, $VC_b(0)=V_d$ and $i(0)=0$, the resonant current i of the 1st mode is

$$i=\frac{\sqrt{2}}{(k^2-1)\omega L}[\cos\omega t-\cos(k\omega t) \tag{2}$$

Here, k is the ratio of resonant and power source frequency.

$$k=\sqrt{\frac{1}{2LC}}\frac{1}{\omega}(C=C_1=C_2) \tag{3}$$

The operation starts at the time of $k\omega t=\pi$, when the current i of the 1st mode is given to an equation (3) and its maximum value. The effective value Ir times $1/\sqrt{2}$ is

$$I_r=\frac{V}{(k^2-1)\omega L}[\cos(\pi/t)+1] \tag{4}$$

3. Inverter Air-conditioner Power System with Low Power Dissipation Type

In this paper, we propose a non-linear capacitance circuit configured with three diodes (D_1, D_2, D_3) and two capacitors (C_1, C_2) as shown in Fig. 4. In Fig. 4, during the current i as flow (a), capacitance is C/2 to make a series circuit, during the current flow as (b), capacitance is 2C to make a parallel circuit. At this time, both ends of the voltage circuit are each done at v, v/2.

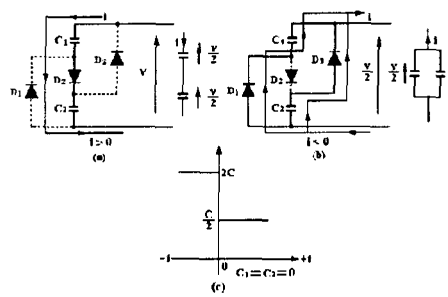


Fig. 4. Non-linear capacitance circuit

By the operation of this circuit, one is able to correct the input current harmonics on rectifier circuits for air -conditioners as shown in Fig. 5.

The operation modes of the proposed rectifier circuits are classified into four modes in Fig. 6, during a positive half period of the input voltage v_s.

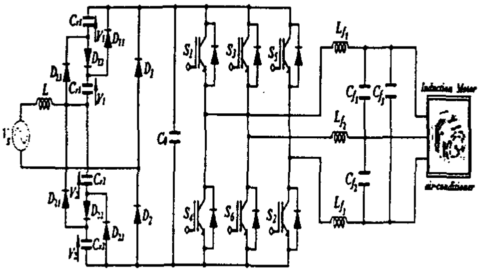
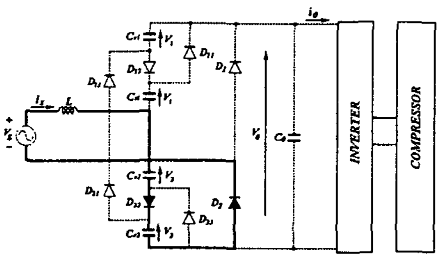
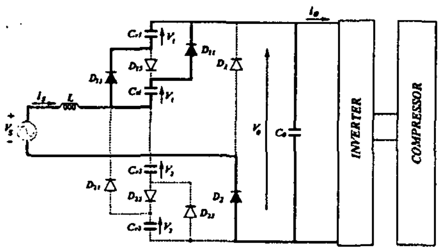


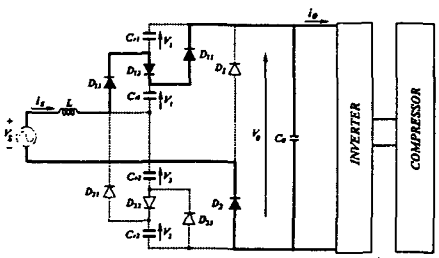
Fig. 5. Proposed rectifier circuit for air-conditioner



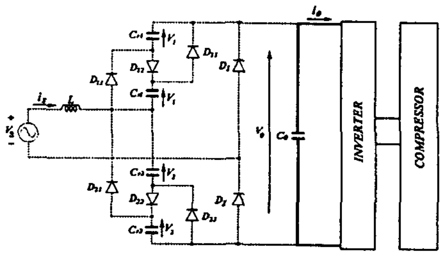
Model



Mode2



Mode3



Mode 4

Fig. 6. Operating modes of proposed circuit

Mode 1 : Input voltage vs is compared to the positive, diode D_{12} and is conducted with the capacitor C_{r2}-C_{r2} which are charged. This charging mode continues until the input voltage reaches a maximum value. At this time, capacitors C_{r2}-C_{r2} are charged to reach the maximum input voltage of $V_m/2$. They are used to fit the case of the positive current i.

Mode 2 : When $v_s+v_1>v_d$, voltage of $V_m/2$ is charged in a capacitor of C_{r1}-C_{r1} and conducted through D_{11}-D_{13}, the current flow to the smooth capacitor C_0, capacitor C_{r1} is slowly discharged, voltage v1 is dropped. This is used to in the case of negative current is.

Mode 3 : When v_1=0, if the input voltage $v_s>v_d$, of the circuit operates like a full wave rectifier circuit.

Mode 4 : As a current is not supplied to the smooth capacitor C_0, by charging the capacitor current flow is loaded.

4. Experimental and Simulation results

Table 1 uses the parameters of the proposed circuit in the simulation and the experiment Fig. 7 show the input current and the voltage waveform of the proposed rectifier circuit by computer simulation. Compared with waveforms of conventional circuits in Fig. 3, the proposed circuit has higher power factor than conventional circuits.

Fig. 8 shows frequency spectrums for input currents of (a) conventional circuits in Fig. 2 and (b) proposed circuits in Fig. 5 by computer simulation. Comparing (a) and (b), we learn that the proposed circuit has low harmonics components. In this paper, the control of this inverter uses HPWM control as shown in Fig. 9.

Table 1. Parameters of proposed circuits

Input Source Voltage v_s		220[V], 60[Hz]
Input Reactor L		6.6[mH]
DC smooth Capacitor C_0		4400[uF]
Capacitor C_{r1}, C_{r2}		157[uF]
Carrier Frequency f_c		2160[Hz]
Modulation Ratio M		0.9
Output Filter Reactor L_f		88.37[mH]
Output Filter Capacitor C_f		8.2[]
Motor	Load Reactor L_r	3[mH]
	Load Resistor R_r	10[uF]

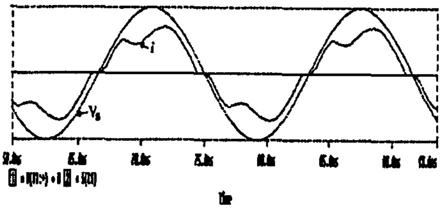
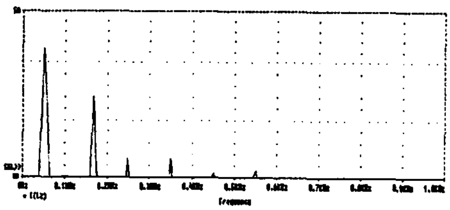


Fig. 7. Input voltage and current waveform


(a) Frequency spectrum of Fig. 2 circuit (conventional)

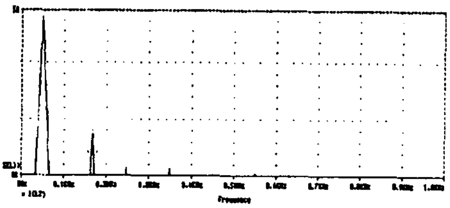

(b) Frequency spectrum of Fig. 5 circuit (proposed)

Fig. 8. Frequency spectrum for input current

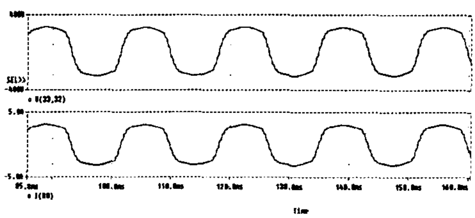


Fig. 9. HPWM control signal waveform

Here, the main switching device of the inverter uses IGBT that is 1MBH40-60 (V_{CE}=600[V], I_C=40[A], T_{off}=640[ns], f_o=20 [kHz]), the reactor L is made from Mn-Zn ferrite core of air-gaps 0.5[mm], 6.6[mH], the capacitorC_{11}, C_{12} ,C_{21}, C_{22} use 157[uF] use an electrolytic capacitor, and are loaded with an induction motor compressor for air-conditioners with the specifications of 60[Hz], 1710[rpm]. Fig. 10 is an experimental apparatus of low power dissipation type power system. Fig. 11 show the comparative data graph that is characteristics of power factor as variation of input voltage of each circuit. Power factor of proposed circuit is not varied to variation of input voltage. And, Fig. 12.

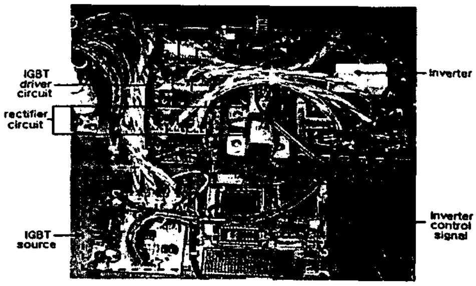


Fig. 10. Prototype of power equipment for air-conditioner

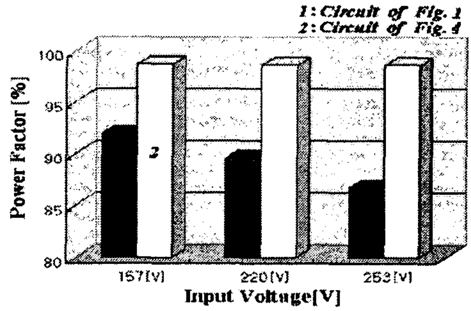


Fig. 11. Characteristics of power factor as variation of input voltage

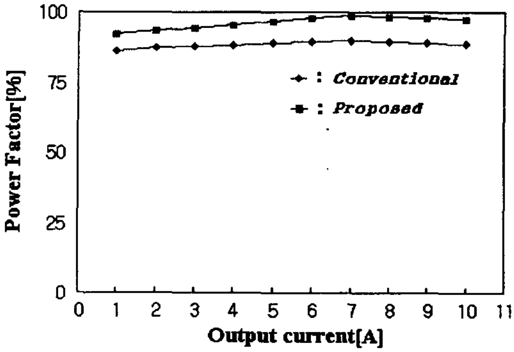


Fig. 12. Characteristics of output current and power factor

Fig. 13 is represents the relationship of phases between the waveform of input voltage and current. Here, the input has a slight unit power factor. In the inverter control signal, we operate sine-wave modulation signals of a modulation ratio of 0.9, and a triangle-wave carrier signal frequency of 2,160[Hz], as Fig. 14 shows HPWM control signals. Fig. 15 is represents the relationship of phases between the waveform of output voltage and current

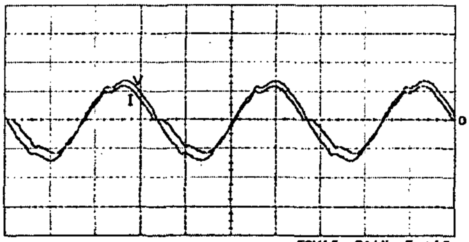


Fig. 13. Waveform of input voltage and current

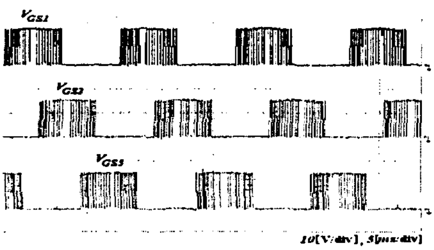


Fig. 14. Control signal of inverter switch

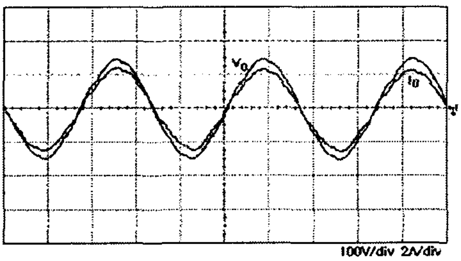


Fig. 15. Waveform of output voltage and current

5. Conclusion

In a conventional power factor correction circuit, a conventional huge capacitor was replaced using a power factor correction circuit, with a small capacitor. In use with a reactor, the input current waveform decreased the rising output voltage. These results show the following results.

(1) By using a passive device, this can be very practical economically; the circuits have a very simple configuration, and do not emit electro-magnetic noise, because they do not use a switching method.

(2) We used two parameters of characteristics based on the circuit parameters.

(3) Harmonics of the power equipment is suitable in the guidelines for harmonics. Maximum efficiency was approximate at about 98[%] and the power factor was 97[%].

The results of these tests were proved through the use of computer simulation and experimentation.

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