High-Efficiency Non-contact Power Supply System

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Abstract – Non-contact power supply (NCPS), as a clean and safe energy supply concept has been applying wildly. Comparing with the conventional transformer the non-contact transformer has a large air gap between the long primary winding and the secondary winding. Due to it, the non-contact transformer has increased leakage inductance and reduced magnetizing inductance. So the high frequency series resonant converter has been widly used on the non-contact power supply system for transferring the primary power to the secondary one, from what a high influence voltage can be gained on the secondry coil even though the large air gap exists. However, it still has the disadvantages of the load sensitive voltage gain characteristics when load is changing. In this paper, we propose a fuzzy logic controller to adjust the frequency of the inverter to track the resonat which is changing when the load is change.

Keywords: Non-contact power supply, Series resonant converter, fuzzy logic control.

1 Introduction

In general, because of the disadvantage of traditional power transformers on inferior connection, water or dust, corrosion, electric shocks and spark might occur. A new power transform system is needed not only to overcome these problems but also to make use of some other advantages, several feasible developments of the non-contact power supply circuit and systems have came into view [1]. The non-contact power supply (NCPS) system by using magnetic coupling instead of using a power cable connection by a carbon brush or a tailing cable can be used as power delivery for where requires a clean room, or a variety of sensitive equipments [2][3]. The configuration of the non-contact power supply system is shown is Figure 1, compare with the conventional transformer the non-contact transformer consists of a long track-cable which is more than tens of meters as the primary winding, and a pickup coil with the large air gap as the secondary one. Because of this, the non-contact transformer is hard to transfer electric power to the secondary coil. Generally, the high frequency series resonant converter has been widely used to solve the problems occurring in the process transferring the energy on the primary side to the secondary coil. But it still has tow disadvantages that is a high and sensitive voltage gain and the low efficiency, due to the difficulty on in-phase control of the primary voltage and current. Although, a series-parallel converter by add a parallel capacitor on the secondary circuit can be used to improve the system. The use of an extra capacitor increases the kVA rating. Since the voltage source series resonant inverter offers the better converter utilization [10]. In this paper another way by improving on IGBT gate controller with Fuzzy logical control conception is proposed to resolve the problem.

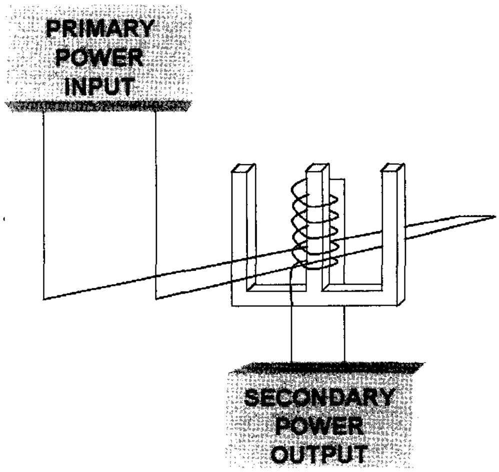

Figure 1. Non-contact transformer configuration

2 System concepts

A NCPS system is shown in Figure 2. The converter operates from an ac supply and provides an isolated dc output, and consists of an input rectifier, a high frequency inverter, a magnetic coupling device (Figure 1), and an output rectifier and reservoir capacitor.

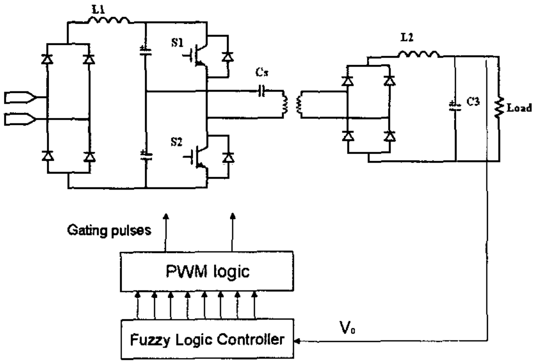

Figure 2. Outline NCPS arrangement

In the NCPS shown in Figure 2, the input from the prime electrical power source is rectified to provide a dc supply to a half bridge high frequency series resonant square-wave inverter which feeds the primary winding of the magnetic coupling device. The secondary winding of the coupling device feeds the output bridge rectifier via a parallel capacitor. The dc side of the output bridge rectifier is connected to a reservoir capacitor which feeds the load. The controller for the system is PWM logic with an adjustable frequency which is control by the fuzzy logic controller.

3 Controller

The high frequency series resonant converter has been widely used as a power supply for the NCPS system. In the resonant converter to maintain a good voltage regulation, the inverter frequency must accurately track the resonance of the secondary circuit. However, since the reduced magnetizing inductance the resonant frequency is sensible when the load is changing on the secondary circuit. Further more, the series resonant converter has the high voltage gain characteristics in the overall load range and because of the difficulty of controlling in-phase of the primary voltage and current. The series resonant converter has the low efficiency and the unstable operating characteristics. It is shown that when the frequency of the inverter tracks well with the resonant frequency a unit voltage gain hold around 2 [2]. With this voltage gain characteristics we propose a Fuzzy logic controller to adjust the working frequency of the inverter by detecting the output voltage. The Block diagram of the fuzzy logic controller is shown in Figure 3.

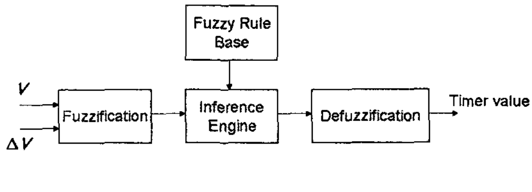

Figure 3. Fuzzy Logic Controller block diagram.

the input for the FLC is out put voltage V of the *inverter and the change of it.* Figure 4. and Figure 5 shows the membership function of input variables, which are with conventional triangular shapes and with 50% overlapping.

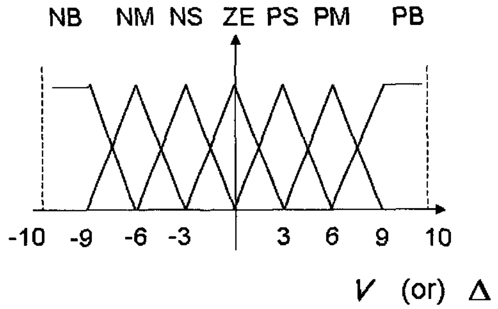

Figure 4. Membership function for input variables

A singleton membership function of output variable DT is shown in Figure 5, which is converted through the center of area (COA) method to yield

$$DT=\frac{\sum_{i=1}^{4} DT_i m_i}{\sum_{i=1}^{4} m_i}$$

Where DT_i is the grade value shown in Figure 5 and m_i is the weighing factor. Whose defuzzification date will send to PWM controller as a adjusted timer value. By what the frequency of the inverter can be changed.

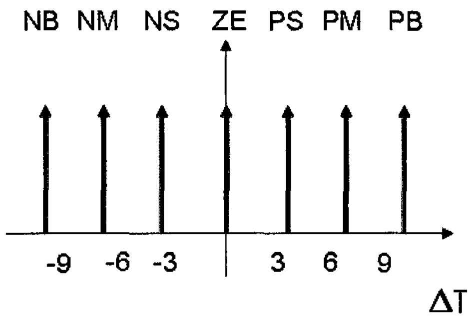

Figure 5 Menbership function for DT

The inference results are show if following table. Based with these rules the value of the timer for the PWM controller will be changed by the data send by fuzzy logic controller. By this way the frequency of the inverter is able to track the resonant frequency which is sensible to the load. And a unit voltage gain inverter can be achieved.

Table 1 Rule base for fuzzy logic controller.

DT / T	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	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

4 Conclusions

In this paper we proposed a fuzzy logic controller to adjust the frequency to track the resonant frequency. By what a voltage gain also can be got. Also the frequency should adjust in the given range on the high frequency of 20kHz. With the advantage on complex and nonlinear problem of the system here the using of this fuzzy logic let the control of the system here becomes possible. On the further research the high efficient characteristics of this power supply system will be proved by experiment.

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