A Study on about Implementation to Induction Cooker that load Turbo Inverter algorithm

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ABSTRACT

The voltage resonating inverter has a defect in the switching element that works at 5 or 6 times higher than input voltage. Especially, it is very difficult to choose very high switching device for the 220[V]commercial voltage.
In this paper, it is proposed the optimum method to realize the turbo 2000[W] power for induction cooker that is employed the 900[V] IGBT with decreasing operating voltage of the switching component by making the 220[V], 1500[W] inverter through the clamp mode voltage resonating inverter.

KEYWORD : voltage resonating inverter, turbo 2000[W] power, clamp mode voltage resonating inverter

1. Introduction

The voltage resonating inverter has a defect in the switching element that works at 5 or 6 times higher than the commercial voltage.[1][2] Especially it is very difficult to choose the switching element over 1500[W] output in the 220[V] commercial voltage, because the switching element operates high voltage in this method. It is appearing a clamp mode to resolve this problem. But existing clamp mode had a difficulty in controlling that the emitter potential of IGBT was different each other.[3]

In this paper, it was easy to control a existing clamp mode when the emitter potential of IGBT is the same position. And it is proposed the optimum control to realize the 220[V], 1500[W] turbo 2000[W] power through the clamp mode voltage resonating inverter.

As a result, the turbo power can be used below 231[V] input voltage and 70℃ heat dissipating plate of a switching element.

2. Induction Heating Cooker

2.1 Existing clamp method

In the picture 2.1, it is an existing clamp circuit. It's hard to control Q2 because of emitter potential differences between switching element Q1 and Q2, and it's difficult to sustain confidence in this circuit.

2.2 Proposed clamp method

The proposed circuit has a strong point that it's easy to control Q2 as a switching element Q1 and Q2 have been emitter common ground and if Q1 resonant voltage is over 600[V], transistor Q3 and Q4 are turn-on and then Q2 is turn-on.

The advantage of this circuit is very simple and makes the clamp circuit compose high stability. Picture 2 shows the proposed circuit.

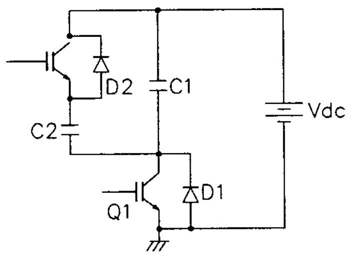

Fig. 1 Clamp circuit of Conventional method

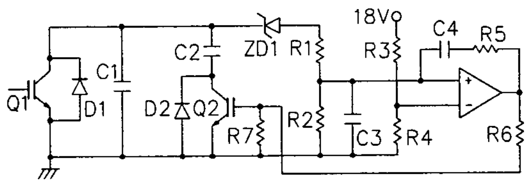

Fig. 2 Proposed clamp circuit

2.3 Proposed clamp mode voltage resonant induction cooker

Picture 3 shows, It is showed the configuration of clamp mode voltage resonant induction cooker. A commercial power supply 220[V] is rectified by bridge diode[BD] and is smoothed by a Capacitor C3. It is supplied induction heating coil L2 with DC power supply through a choke coil L1 and a smoothing Capacitor C4. IGBT(Q1) was used as a switching element and the collector and emitter of IGBT are connected with a resonant Capacitor. The resonant Capacitor is connected with a clamp circuit which is consisted of Capacitor C2 and a switching element Q1.

A signal which is rectified through a diode D1,D2 in power input is used as movement source an inverter control unit. There are two switching control. One, switching control 1, that is a current transformer from a terminal of source, sensor of input current, comparison

both sides of voltage in induction heating coil L2 and then, is to control on-signal of IGBT. The other, switching control 2, works for IGBT act in the clamp circuit.
Micom control signals departed power from power supply and then controlled input power.
Micom is consisted of signal control units to return inverter signal to Micom.

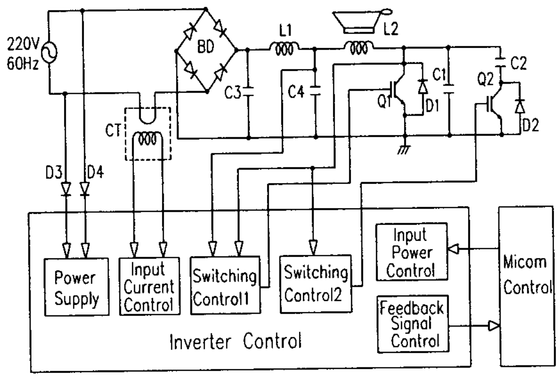

Fig. 3 Configuration of Clamp mode voltage resonant Induction cooker

2.4 Turbo output algorithm

Picture 4 shows a turbo algorithm flowchart. Commercial input voltage and switching element are possible to work turbo output in only low temperature.
As an experiment result, Turbo output works below input voltage 231[V] and heat dissipative plate temperature 70℃ of a switching element.

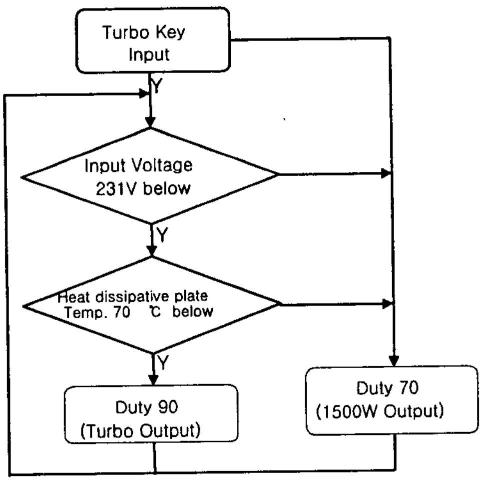

Fig. 4 Turbo algorithm flowchart

When we control turbo output, we can control input power control as a duty rate 90% and we can also control as a duty rate 70% in case of 1500[W](general output).Picture 5 shows circuit configuration for sensing input voltage and heat dissipating plate's temperature.

Picture 6 shows input power control signal into turbo output and regular output(1500[W]).

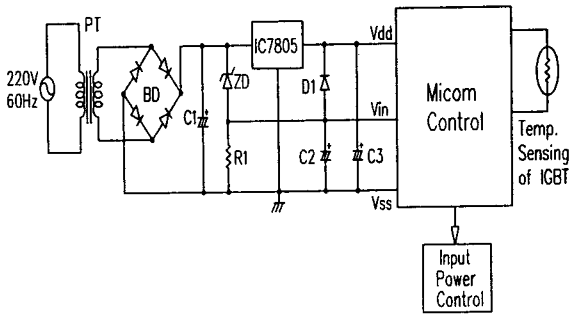

Fig. 5 Configuration circuit of turbo algorithm

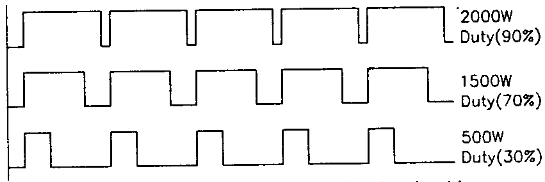

Fig 6. Input power control signal of turbo algorithm

2.5 The design of inverter circuit

A. IGBT turn-on and turn-off time decision

When we set up the 40kHz of oscillating frequency for inverter a period is t_f

$$t_f = \frac{1}{f} = \frac{1}{40 \times 10^{-3}} = 25[\mu s]$$
$$t_f = t_{on} + t_r + t_d$$

Where, t_{on} : IGBT turn-on time
t_r : IGBT turn-off time
t_d : Damping diode flowing time

We've set up ton=10[µs], tr=13[µs] td=2[µs] to the voltage resonating inverter.

B. The capacity decision of smoothing Capacitor(C4) and heating coil(L2) inductance

$$\text{Input power} \quad p_i = \frac{1}{t_f}\int_0^{t_s}[V_i(t)I_c(t)]dt$$
$$= \frac{V_i^2(t)}{2t_f L_2}(t_{on}^2 - t_d^2) \qquad (1)$$

Where, V_i : Average input voltage
L_2 : Heating coil inductance

$$i_c(t) = \frac{V_i(t)}{L_p} t_{on} \qquad (2)$$

When IGBT is turn-on and accumulated energy starts to move in smoothing Capacitor to heating coil, Vcc(t) voltage is decreased. When Ec is $3.56E_L$, Vcc(t) is decreased approximately 28% and Vcc(t) is an average input voltage at this time.

$$V_i(t) = \frac{V_{cc}(t)(1+0.72)}{2} = 0.86Vcc(t)$$

$$\therefore Vcc(t) = 220 \times 0.86 = 189.2[V]$$

It was calculated 2000[W] standard heating coil inductance.

$$L = \frac{V_i^2(t)}{2t_f \times P_i}(t_{on}^2 - t_d^2) = 34.4[\mu H]$$

At this time, the resistance value of heating coil is 4.3[Ω].(standard 40kHz)

$f_{0=}\frac{1}{2\pi\sqrt{LC}}, t = \frac{1}{f_0}$ Frequency works damped vibration by heating coil resistant component.

$$t_r = \frac{4}{3}\pi\sqrt{LC}$$

$$C = (\frac{3}{4\pi}t_d \times 10^{-6})^2 \frac{1}{L} = 0.238[\mu F]$$

t_r is usually $\frac{2}{3}t$ of standard and C1=0.1[μF], C2=0.4[μF] are selected. If IGBT turn-on time is 10[μs] collect peak current $i_c(t)peak$ is

$$i_c(t) = \frac{V_{cc}}{R}(1 - e^{-\frac{R}{L}t}) = 65[A]$$

Picture 7 shows the voltage, current waveform in proposed clamp method.

3. The result of Experiment

In table 1, there are measurement values, as a experiment result, for IGBT resonant voltage, current and input power when we change turbo output standard input voltage from proposed clamp mode voltage resonating inverter.

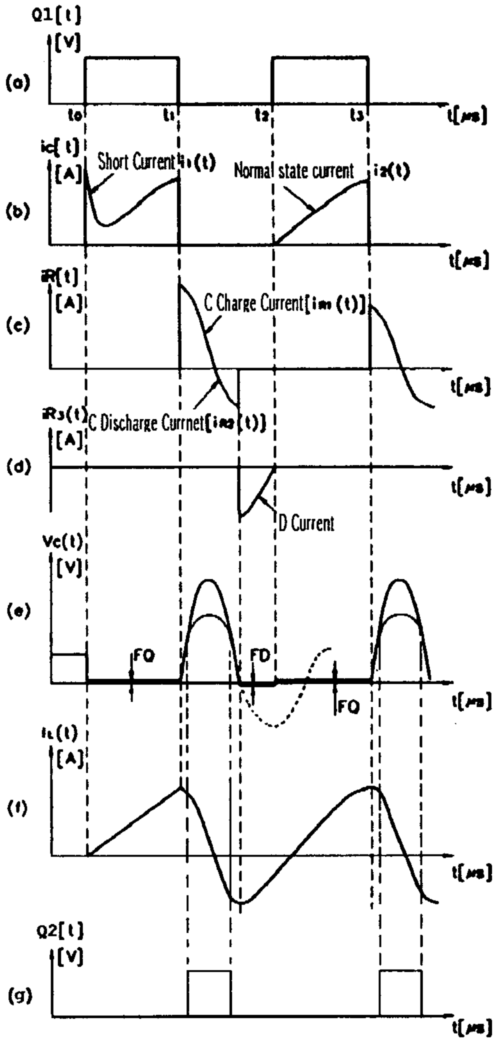

Fig. 7 Inverter waveform of clamp mode voltage resonant

Table 1. Characteristics of proposed Induction cooker

Item \ Input Voltage[V]	198	220	242
Oscillating Frequency[KHz]	36.9	39.8	41.0
Resonant Current[A]	61.8	65.3	68.0
Resonant Voltage[V]	584	624	670
Output[W]	1850	2000	1950

* base on removed input voltage detection circuit

Picture 8, 9, 10 shows voltage and current waveform when we make voltage change. We could know this picture that frequency is decreasing while voltage, resonating voltage, and current are increasing.

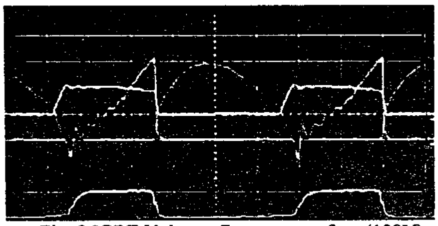

Fig. 8 IGBT Voltage, Current waveform(198V)

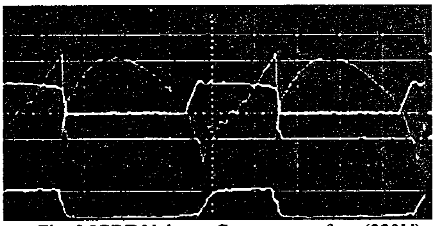

Fig. 9 IGBT Voltage, Current waveform(220V)

Fig. 10 IGBT Voltage, Current waveform(242V)

4. Conclusion

In this paper, existing clamp mode has a problem that is low credibility to control different emitter voltage of IGBT. So it is proposed this circuit how to resolve this problem when the emitter voltage of IGBT has the same voltage.

This circuit using generally IGBT 900[V], 60[A] showed turbo output 2000[W] and we confirmed that it has stable output in voltage change 10%.

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