

## *A Driving Method of a Square Waveform Inverter Circuit Using Power Transistors*

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### Synopsis

In recent years, the development of a high power transistor element is proceeding. A high power inverter circuit using power transistors are finding a good number of applications in induction heating and melting.

Turn off time of power transistors occupies 5~10 $\mu$ s of switching characteristics.<sup>1),2)</sup> A driving method to give base inputs for a half period is widely used for a inverter circuit. But this method has the following defects, the short-circuit current flows through two transistors because the other pair transistors turn on before one pair transistors turn off. So the switching loss is increased, the maximum output and the efficiency are decreased.<sup>3)</sup>

In this paper, a driving method to give base inputs for the less period as compared with a half period is discussed. Using this method, the foregoing defects is lost and the driving frequency is able to become higher. In addition, it become clear that the square waveform output is given using this method in the case of R-L load.

### 1. Introduction

The square waveform inverter circuit with transistors is shown in

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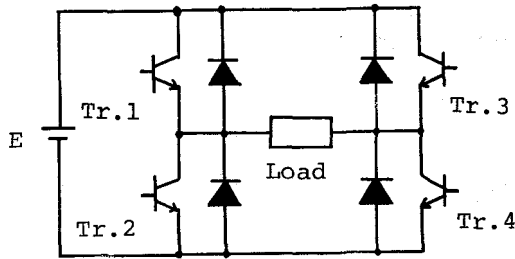


Fig.1. Inverter circuit with transistors.

Fig.1. The behavior of the circuit in the case of the base drive input is added over the full period of a half cycle is shown in Fig.2. The turn-off time measuring circuit is shown in Fig.3. In Fig.4, the waveforms of the base input current  $i_b$  and the collector current  $i_c$  are shown. The variations of the turn-off time to the collector current are shown in Fig.5. It is evident that there is the short circuit current flowing through the tran-

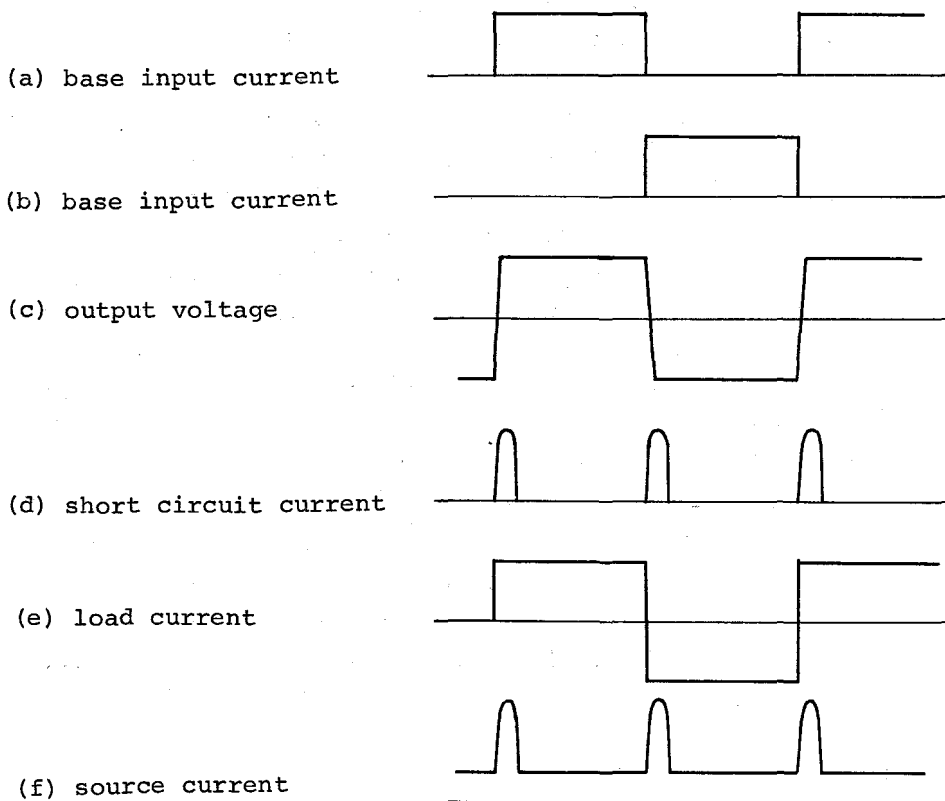


Fig.2. Waveforms of the inverter circuit in the case of the resistive load.

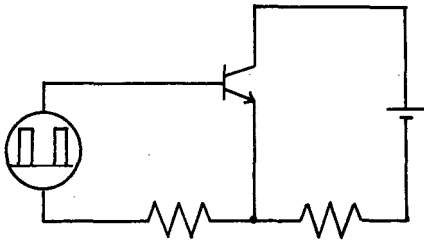


Fig.3. Turn-off time measuring circuit of transistor.

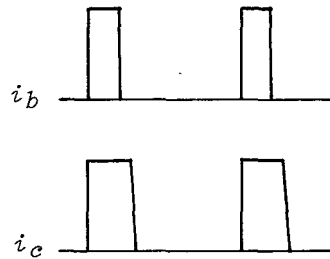


Fig.4. Waveforms of the base current  $i_b$  and collector current  $i_c$ .

sistors, Tr.1 and Tr.2, from Fig.4, Fig.5 and Fig.2(f).

## 2. Improved driving method

To remove the short circuit current through the two transistors on the commutation, it is necessary that a pair of transistors is turned off before the other pair of transistors is turned on.

So, it is necessary that the base input of a transistor is put on in the less period than the period taking off a turn-off time from a half cycle period.

Let's call this type "the rest driving method". The other side, the base input is put on for a full half cycle, let's call "the full driving method".

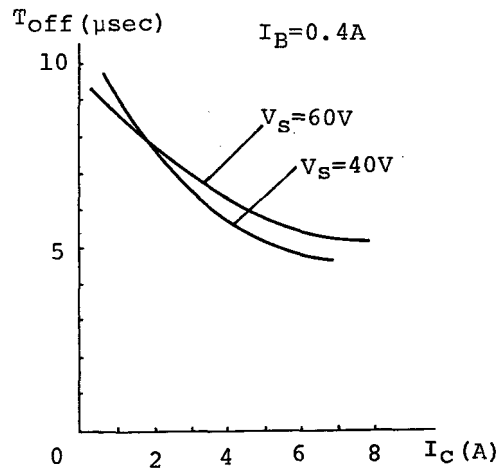


Fig.5. Turn-off time of transistor.

## 3. The rest driving method and the inductive load movement

The movement, when the base input that is shorter enough than the period of a half cycle is given to the inverter circuit with the inductive load, is shown in Fig.6.

In the case of the inductive load, there is a period that is fed back the reactive power from the load to the source through the diode. The instant that the transistor is turned off, the reverse voltage  $-E_s$  is induced on the load terminals. And then, the load current is

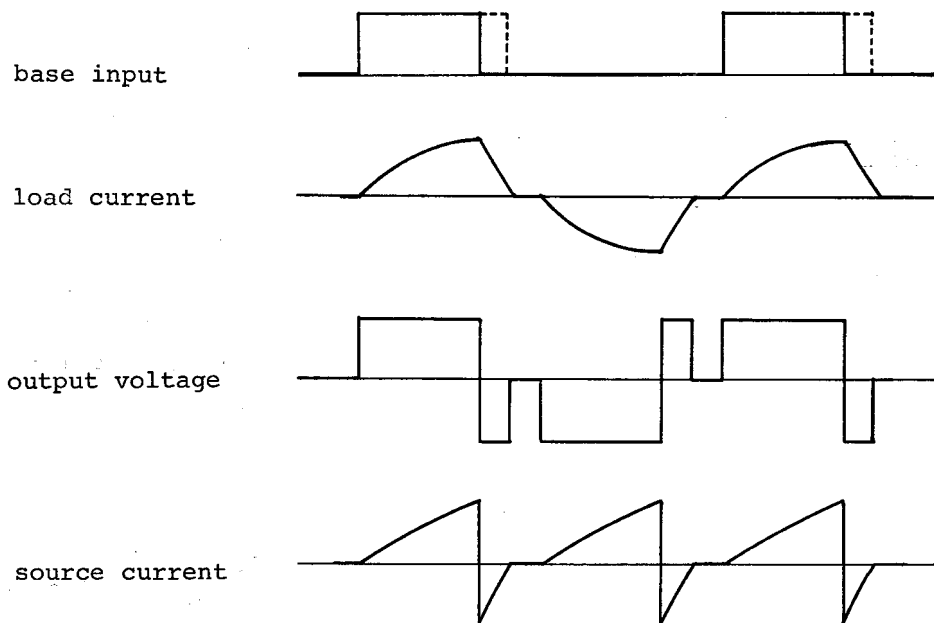


Fig.6. Waveforms with the inductive load.

zero, the out-put voltage is zero, two.

The feed back period increases in proportion to decreasing the power factor of the load.

In the feed back period, the next transistor current doesn't flow for the incerse voltage of the diode, even if the next transistor is turned on. And then, if the diode current is zero, the transistor current flows instantly, and the direction of the load current changes, but the load voltage is not change. So, if the rest time of the base driving input is shorter than the feed back period, the out-put voltage is a square wave.

#### 4. Experiment result

The short circuit current waveform is shown in Fig.7, the source current is measured in stead of the short circuit current under the conditions of the light load current and the full driving method on the circuit in Fig.1.

The relation of the base drive time to the short circuit current (mean value) is shown in Fig.8. The efficiency characteristics is

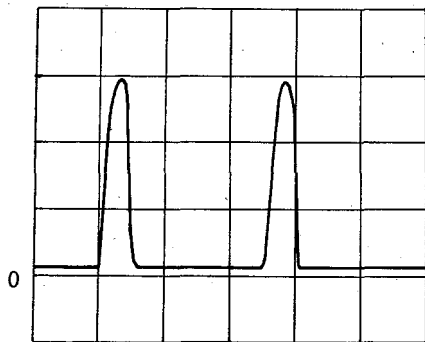


Fig.7. The short circuit current waveforms.  
 5A/div, 10 $\mu$ s/div,  $V_S=60V$ ,  
 $f=20kHz$ ,  $R_L=6000\Omega$

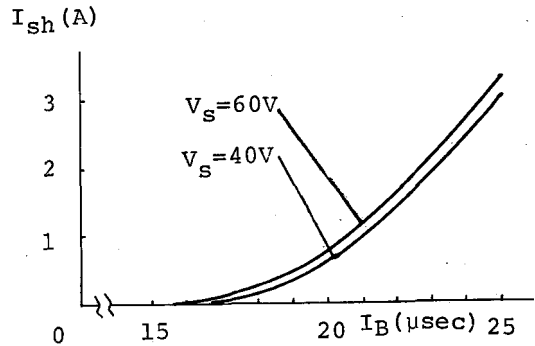


Fig.8. Base drive time to short current.  
 $f=20kHz$ ,  $V_S=60V, 40V$

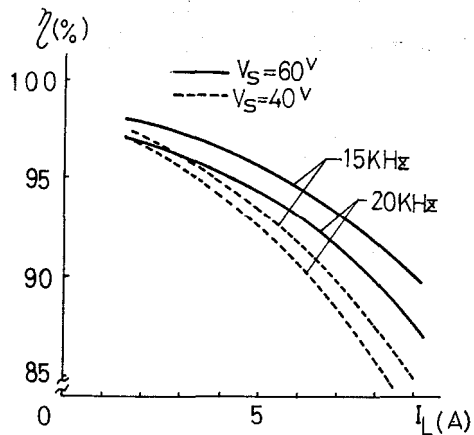


Fig.9. Efficiency characteristics.

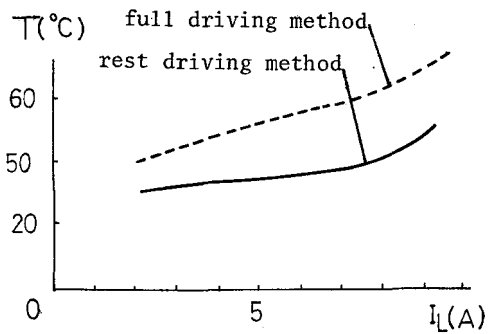


Fig.10. Temperature characteristics of transistor case.

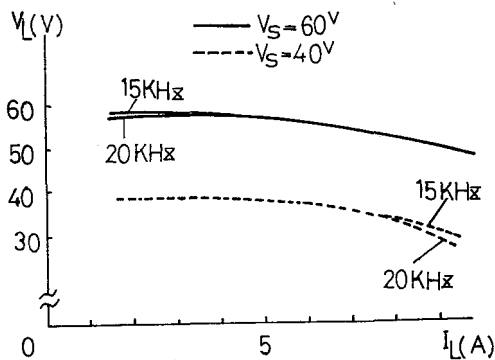


Fig.11. Load characteristics.

shown in Fig.9, the temperature characteristics of the transistor case is shown in Fig.10, the load characteristics is shown in Fig.11.

### 5. Discussion

In the case of the full driving method, the large short circuit current flows in proportion to the driving frequency.

In the case of the rest driving

method, the short circuit current decreases in inversely proportional to the rest time, when the time is within turn-off time of a transistor.

## 6. Conclusion

On the square wave inverter circuit with power transistors, the disadvantages of the full driving method are pointed out, and the rest driving method is described as the means of solving, and it is shown this method is effective.

## References

- (1) JOHN.L.MOLL, *Proc.I.R.E.*, p.1773~1784, Dec.(1954)
- (2) Nihon Electric Co., *Electronics Data Book*, p.311, (1969)
- (3) Iwakane, et al., *Technical Report of Yasukawa Denki*, No.4, p.574~587, (1974)