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AN EXPERIMENTAL INVESTIGATION OF BRUSHLESS AND SELF EXCITED SINGLE PHASE SYNCHRONOUS GENERATOR

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ABSTRACT

The use of three phase winding with two diodes in the rotor of single phase brushless and self excited synchromus generator is investigated. In this paper the three phase winding are used in the stator to give a five methods of winding arrangement.

This paper presents an experimental investigation for these five connections. To choose the best stator connection the rated stator phase current is used as a base of comparison. A new method of stator winding arrangement is proposed and gives an output voltage of nearly sinusoidal wave form and high output power

KEYWORDS: Synchronous generator; brushless; self-excitation, rectification; wave forms; performance characteristics.

INTRODUCTION

Small AC generators are often used in various practical applications, such as emergency supply, low level power generation, at remote and isolated areas and for a portable source of power supply at construction cites. It has been found particularly required that the construction of such a generator is simple, robust, and reliable.

A large number of attempts has been made by some authors in the development of brushless, and self excited single-phase synchronous generator. Noraka (1) presented the original brushless self excited generator, in which unsymmetrical two stator windings are used, one is connected to the exciting capacitor and the other is connected to the load. The rotor has two symmetrical windings, with diodes are connected to them to constitute a half-wave rectification. This results in quick voltage build up. Referance (2) found that a displacement angle of 90° degrees in space between the two stator windings leads to increased power supplied to the load and also improved efficiency and regulation are achieved. On the other hand, references (3,4,5) investigated the use of three phase slip ring induction motor in the experimental work, as a single phase brushless generator, by different methods of stator connection. In this work, two new methods of stator windings arrangement are proposed and experimentally investigated. Comparison between the characteristics obtained from these methods and three methods proposed in the literature, is given. (Fig. A) shows the connection diagram of the connection A, in which two stator phases are used, one as exciting winding and the other as load winding. Connection B is the first proposed connection in which phases A and B are connected at the neutral point, and then shunted by a capacitor. The load is connected across phase A. In connection C (3) the two stator phases A and B are connected at the neutral point to act as load winding. The third phase is used as exciting winding, connected with capacitor. Reference (4) suggested a star connection of stator phases, the load is connected between two lines, and the capacitor is connected as shown in Fig. D. The second proposed connection in this paper is shown in Fig. (E).

This paper presents an experimental study of the single phase brushless synchronous generator under these five connections of the stator phases.

In this type of generators, the rotor residual flux produces an AC e.m.f in the stator winding during the rotor rotation. Applying a suitable capacitance on any stator winding, leads to an AC current in this winding by the same frequency of conventional synchronous generator. This stator capacitive current produces a stator pulsating field. The stator field will be equivalent to two rotating fields. A forward rotating field will not produce any e.m.f in the rotor winding. The stator backward rotating field produces a rotor excitation e.m.f by the double of stator frequency. The rotor e.m.f with the two diodes, gives the rotor DC excitation. The degree of the generator saturation and capacitance value will keep both capacitor current and rotor current at the desired values.

2. EXPERIMENTAL INVESTIGATION:

The experimental measurements are carried out on a three phase wound rotor induction motor of 240 V, 0.35 A, 4-pole, 50 HZ. The rotor windings are connected to two diodes, by one method, but the stator windings are connected to the capacitor and load by the five connections shown in Figs (A to E). The generator is loaded by a resistive load. In the five connections, when the capacitance value is increased, its winding current will be increased. Also, when the load current is increased, some winding current will be increased. For the sake of comparison, the value of capacitance is chosen to give the higher value of current, in each connection, equal to the same rated current of the winding.

3. GENERATORS CHARACTERISTICS AT NO LOAD:

Variation of no-load voltage, capacitor current, capacitor voltage, and the rotor currents against capacitance are shown in Figs (1,2,3,4,5). The increasing of the capacitance leads to increased capacitor current and consequently increased rotor current and no-load voltage. The connection (E) needed the smallest capacitance to build-up the generated e.m.f, while connection (A, C) needed the highest capacitance to build-up the generated e.m.f.

The capacitance value cannot be chosen from the no-load tests only, but the load tests are necessary for this choice. This is due to the increasing of some winding current with load current. From both the no-load and load tests, the capacitance is chosen to be 3.8 μf for connection A, 1.5 μf for connection B, 3.8 μf for connection C, 1.5 μf for connection D and 1.4 μf for connection E.

4. GENERATORS LOAD CHIRACTERISTICS:

Fig. 6 shows the variation of load voltage versus load current for different connections at constant speed (n = 1500 r.p.m).

In connection A, B as the load current increases the terminal voltage is decreased by small value due to the increase of the capacitor current Fig. (7), and consequently the increase of field current Fig. (8). Thus the generated e.m.f is also increased. These two connections have the lower values of voltage regulation.

In connections C, D and E, the load voltage is higher than of connection A and B. But higher ratio of voltage drop, with load current than in A and B. Therefore, the generator regulation is higher in connections C, D and E than in A and B. Fig. 8 shows the variation of capacitor voltage against the load current for different connections. The connection (A) needs capacitor having a working voltage about 250 v, while connection (B) needs capacitor has operating voltage of 430 v. Connection C needs capacitor of about 250 v. Connection (D) needs capacitor having rated voltage of 460 v. Connection (E) needs capacitor having a 570 v.

Fig. 9 shows the variation of the two diodes current with load current. The two diodes are connected symmetrically in the rotor circuit. But, the direction of rotor rotation leads to difference between both diode. Currents connection (E) gives the highest rotor diodes excitation current, with higher ratio of increasing, to improve the generator regulation. The current in the stator phases is different from phase to the other. To avoid any over heating of stator winding, the current in the stator phase of higher current, for each connection is given in Fig. 10. In connection (A), as the load current is increased the current in phase C is constant. In connection (B), the current in phase A is increased with load current. In connection (C) as the load current is increased the current in phase C is decreased. In connection (D) as the load current is increased the current in phase B is increased by the higher ratio than the other connections. So that the load current can not increased to the same values of the other connections. In connection (E) as the load current is increased the current in winding AB is increased. Fig. 11 gives the out put power versus load current for different connections. Connections (A, B) give the lower out put power. While connection (E) gives the higher out put power.

Generator efficiency is determined from the experimental results, when the losses are considered as the copper losses in the stator and rotor winding. The iron losses are ignored and thus the effect of wave form harmonics on the iron losses is ignored. Fig. 12 shows the variation of generator efficiency with load for different connections. Generator efficiency with load current for different connections. Generator efficiency with connection (C) gives the highest efficiency. With connection (E), the efficiency is lower. But when the iron losses are taken into account, efficiecy of connection (E) will be improved with respect to the other connections due to its good wave forms and thus lower harmonics.

5. GENERATOR WAVE FORMS

In this type of generators, the rotor excitation current is not pure DC, but has a ripiples due to the diodes. The arrangement of stator winding and the choosing of the coil which is connected to the capacitor, leads to an improvement of output voltage form. Figs (13,14,15,16,17) show the wave forms of output voltage, capacitor voltage and current, diode current and thus rotor currents for different connections, at no load the wave form of output voltage for connection (E) is nearly sinusoidally than for other connections.

CONCLUSIONS

Experimental investigation of single phase brushless self excited single phase synchronous generator is achieved in this paper for five methods of stator winding arrangement. New method (connections E) is proposed in this paper, which gave the following advantages:

1. Nearly sinusoidal output voltage, with lower harmonics than the other connections.
2. Needs a smaller capacitance than the other connections.
3. Higher output power and current can be supplied to the load.
4. Higher output voltage is obtained.

The advantage of both connections A and B is the low voltage regulation. While the advantage of connection C is the high efficiency. The load current and output power is small in connection D.

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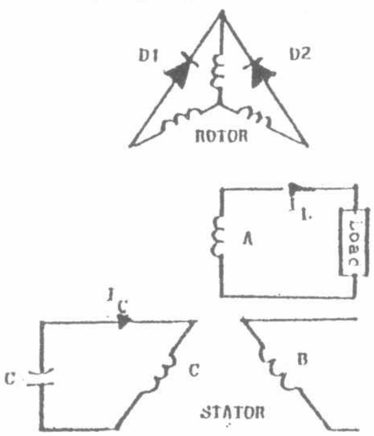

Fig. A. Connection A

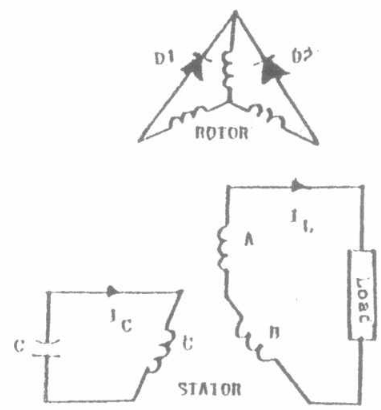

Fig. C. Connection C

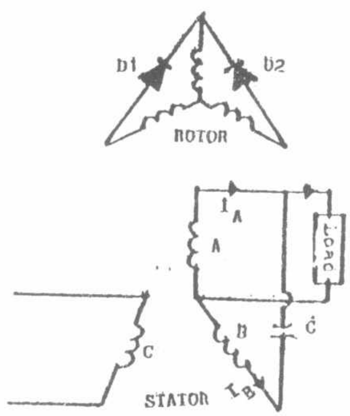

Fig. B. Connection B

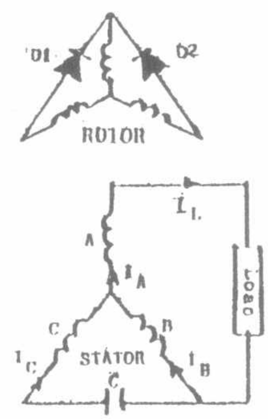

Fig. D. Connection b

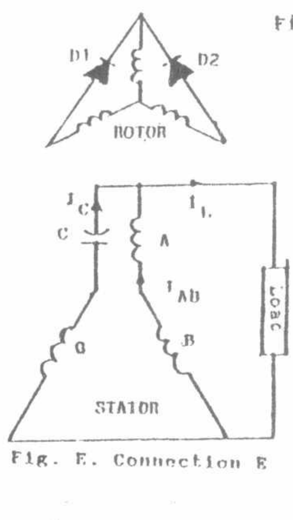

Fig. E. Connection E

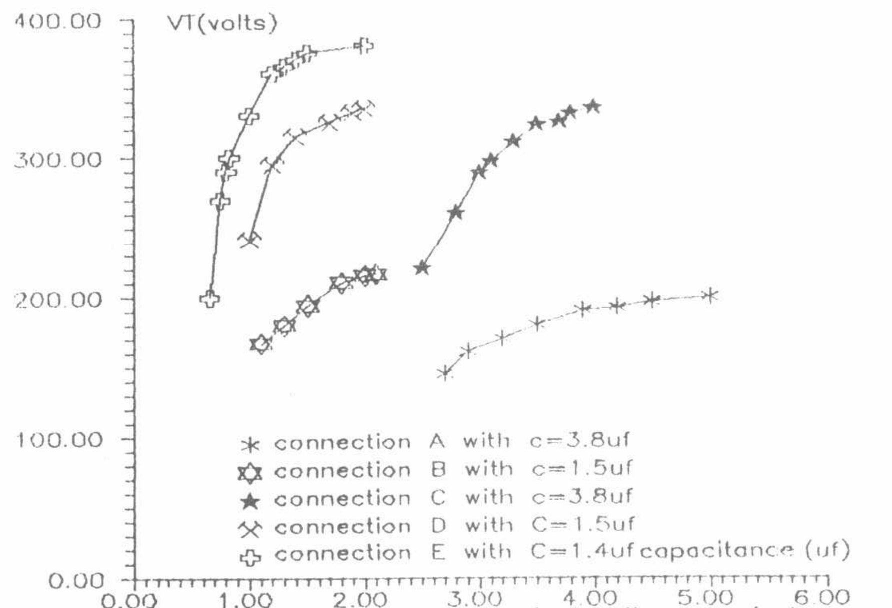

Fig.1 Variation of no-load terminal voltage against capacitance values for differennnnnnnnt connections

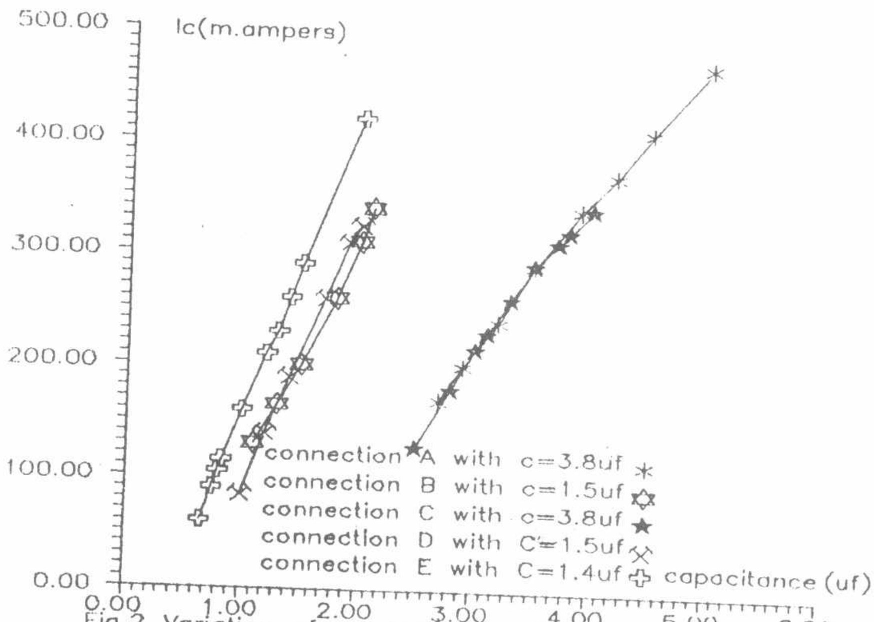

Fig.2 Variation of no-load capacitor current against capacitance values for different connections

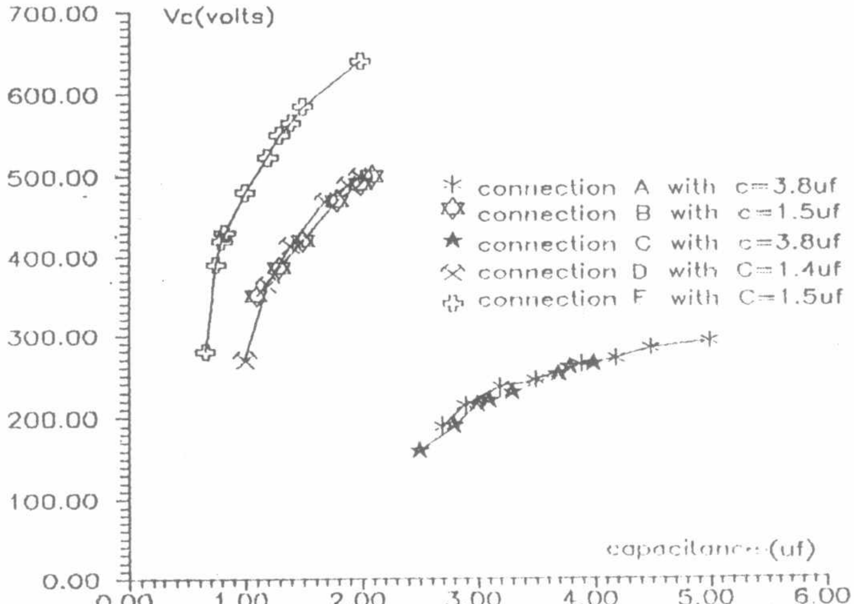

Fig.3 Variation of no-load capacitor voltage against capacitance values for different connections

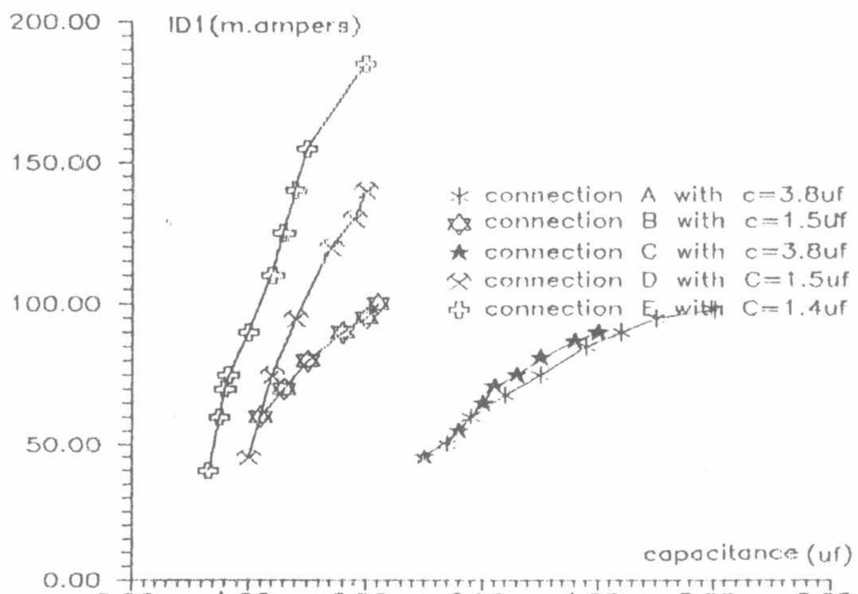

Fig.4 Variation of no-load DC rotor current id1 against capacitance values for different connections

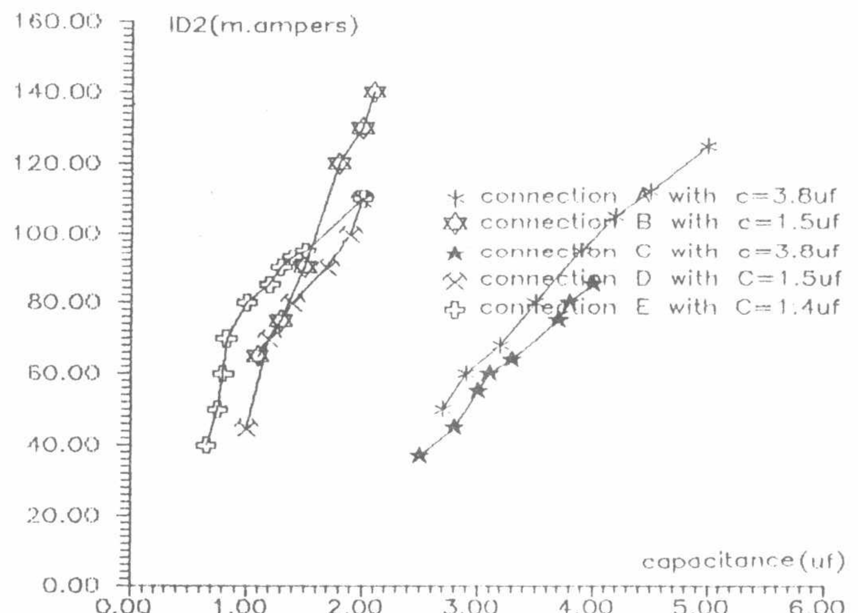

Fig.5 Variation of no-load DC rotor current id2 against capacitance values for different connections

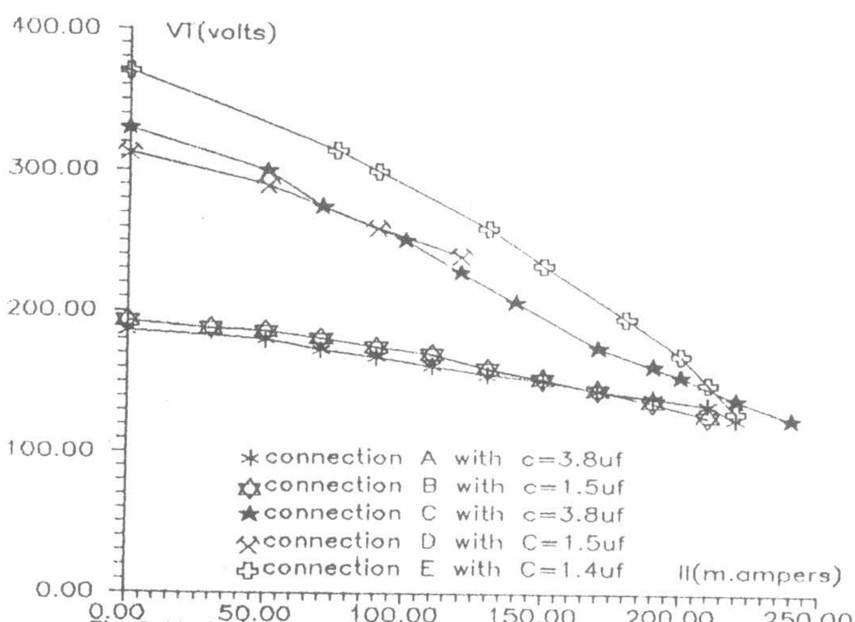

Fig.6 Variation of load voltage against load current for different connections

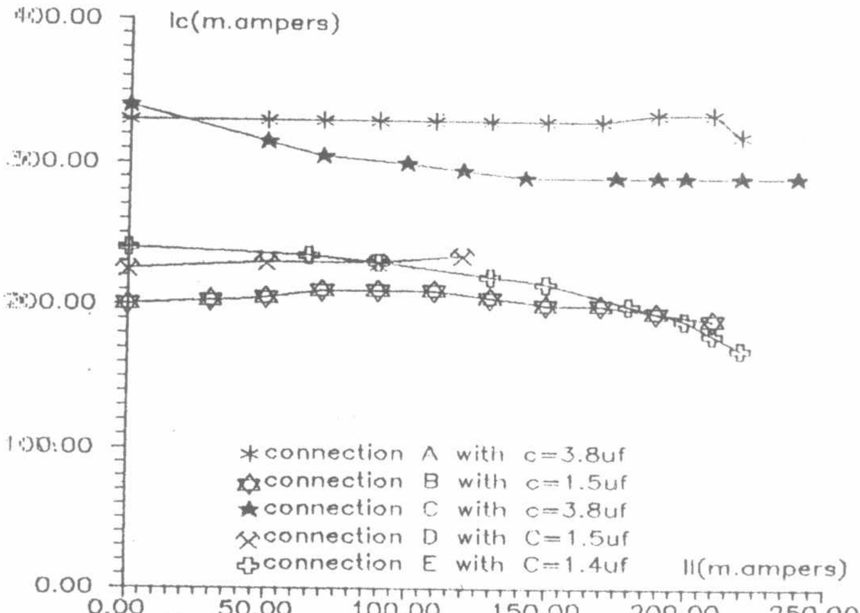

Fig.7 Variation of capacitor current against load current for different connections

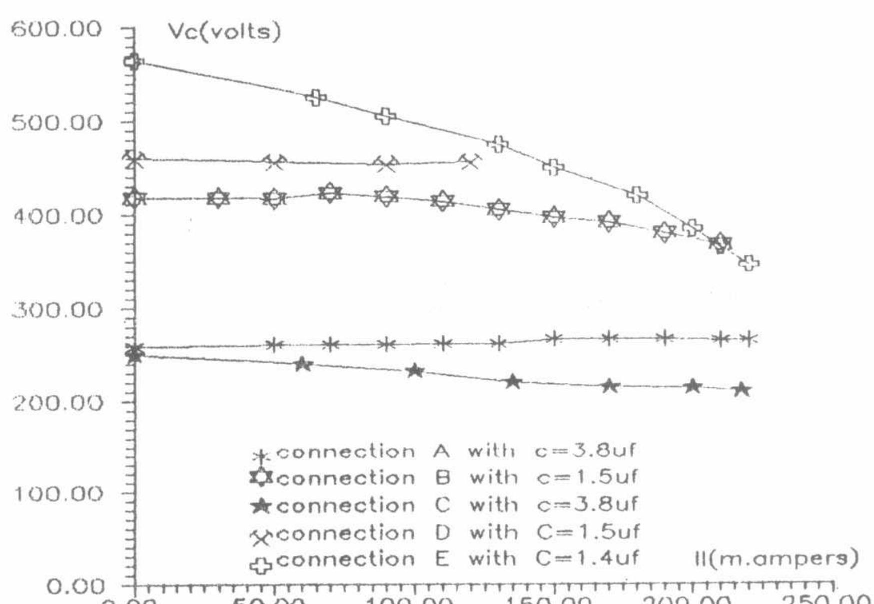

Fig.8 Variation of capacitor voltage against load current for different connections

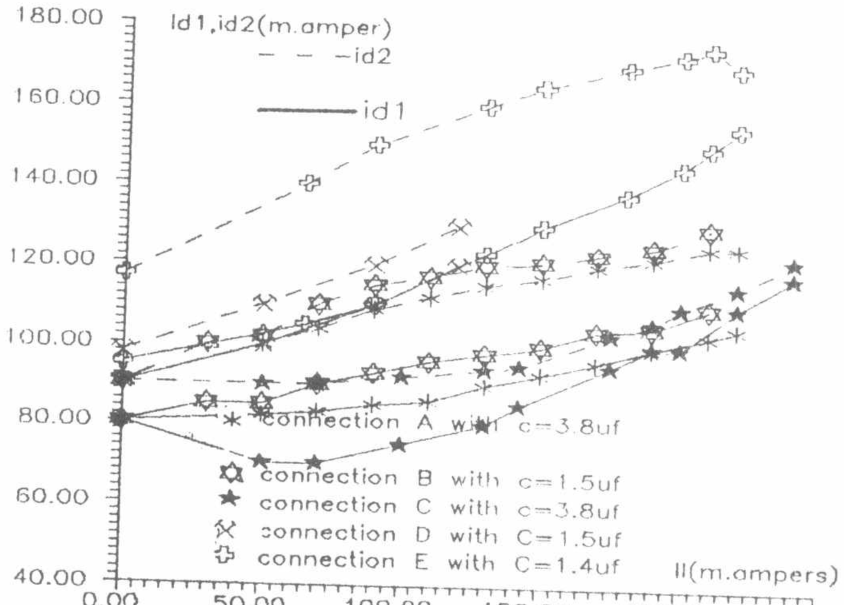

Fig.9 Variation of diodes current against load current for different connections

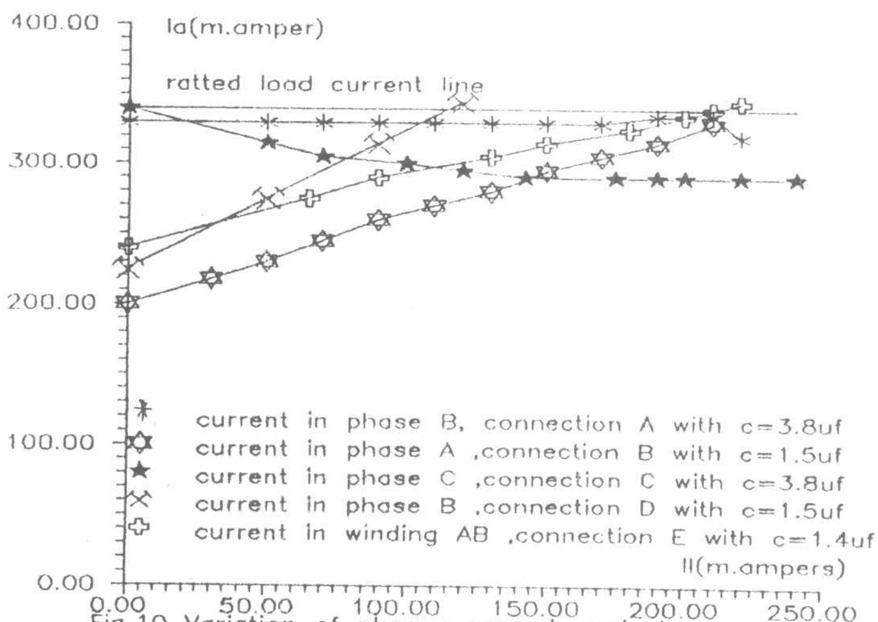

Fig.10 Variation of phases current against load current for different connections

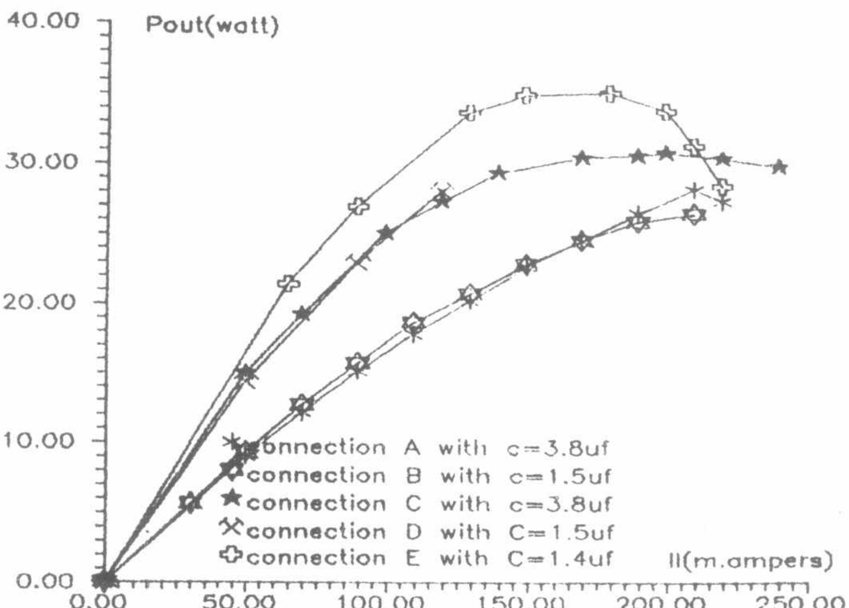

Fig.11 Variation of load power against load current for different connections

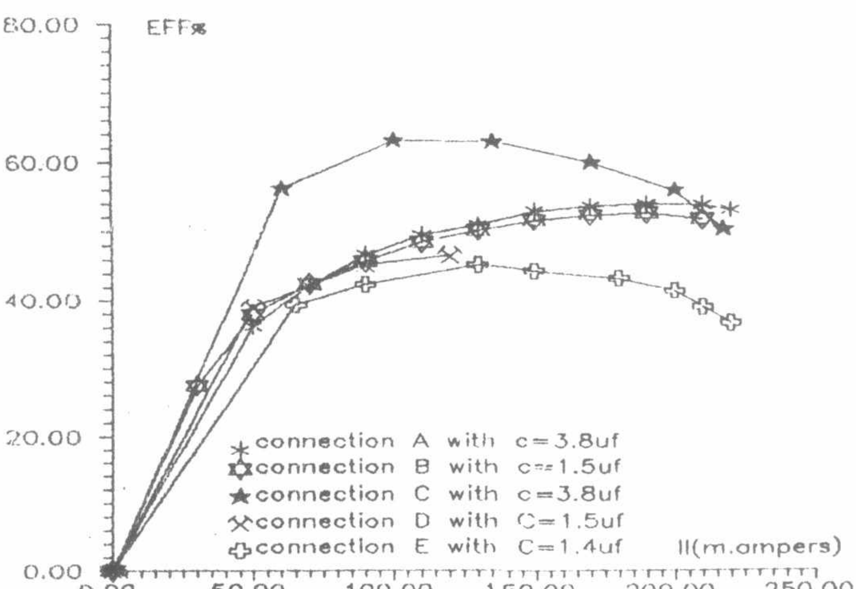

Fig.12 Variation of efficiency against load current for different connections

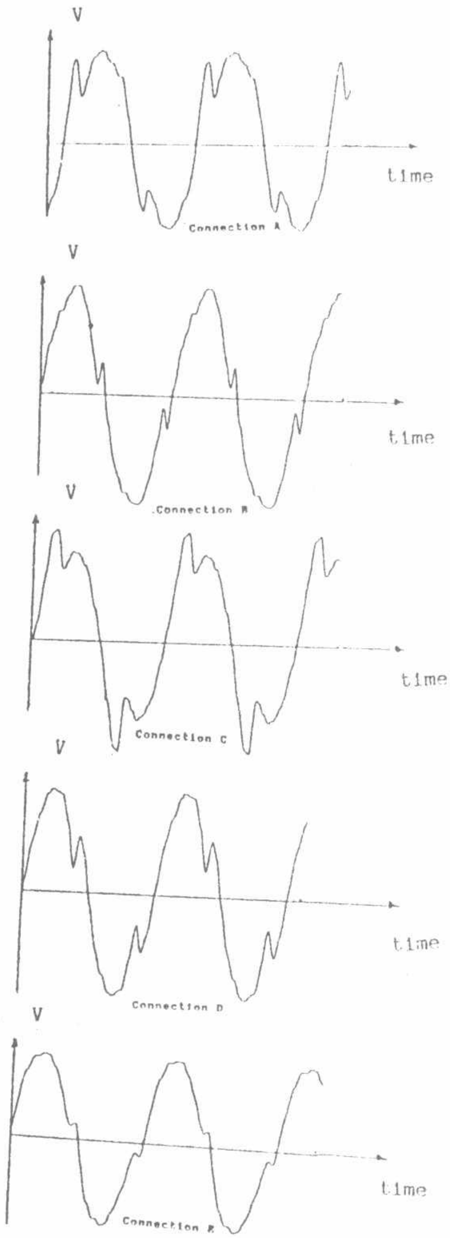

Fig. 13. The no-load voltage wave forms for the different connections

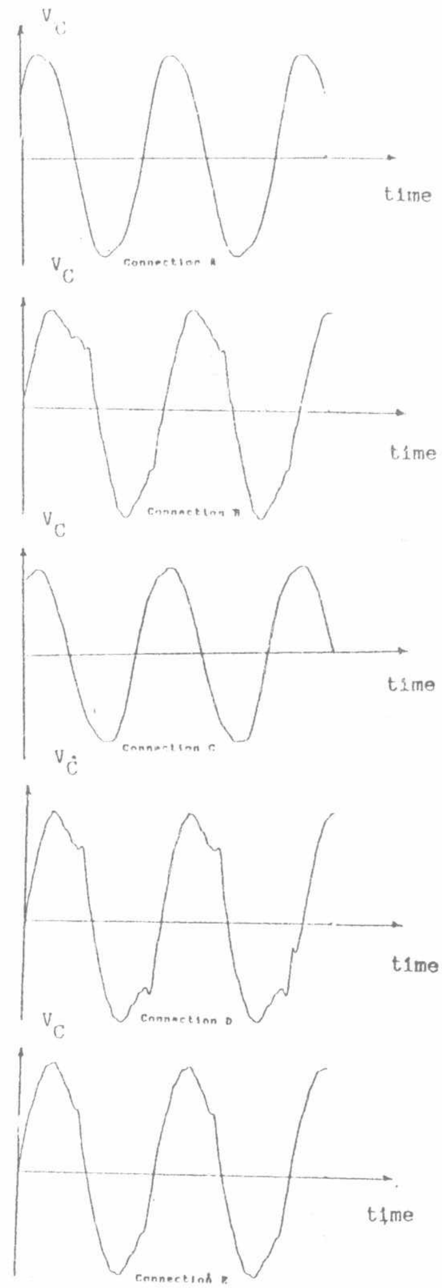

Fig. 14. The no load capacitor voltage wave forms for the different connections

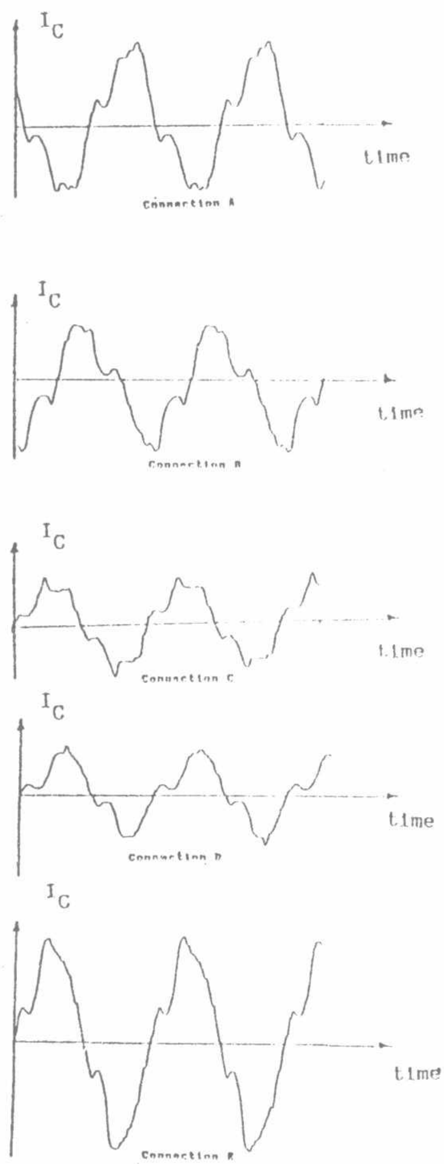

Fig. 15. The no-load capacitor current wave forms for the different connections

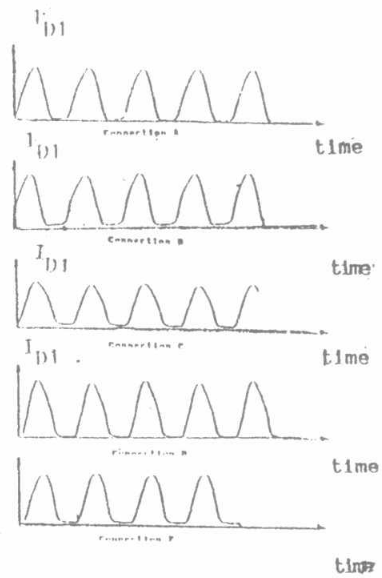

Fig. 16. The no-load DC diode current ID1 wave forms for the different connections.

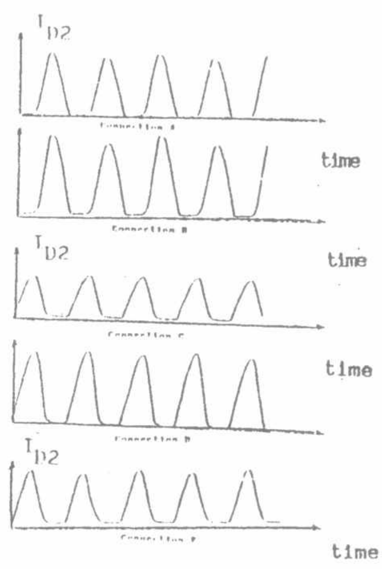

Fig. 17. The no load DC diode current ID_2 wave forms for the different connections.

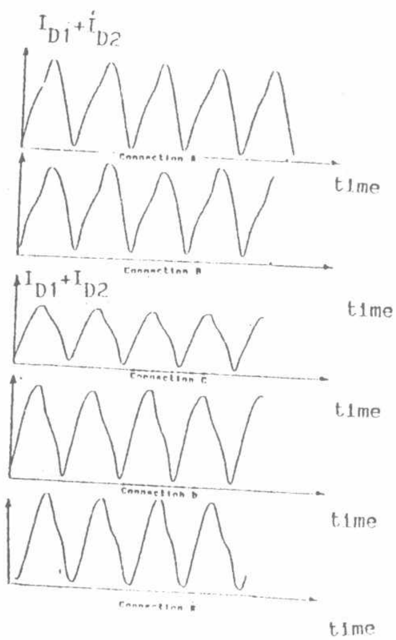

Fig. 18. The no load DC current (ID_1 + ID_2) wave forms for the different connections