Mansoura Bulletin Vol. 10, No. 2, December 1985 E. 85

Microprocessor-controlled AVR of an electrical power Generating unit

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ABSTRACT :

The paper presents a microprocessor closed-loop-like control scheme for an automatic voltage regulation (AVR) and reactive power compensation at the terminals of a dc-motor driven synchronous generator. The experimental set-up consists of the electrical-power generating unit, a single-phase thyristor-type excitation system, the microprocessor application trainer MAT-385 of Feedback and necessary prephirals. Supervisory programmed algorithms have been developed and the whole control system is put in working order for test. Laboratory experimental investigations showed satisfactory performance. The terminal voltage has been maintained within the standard limits for both and sudden load fluctuations. Additional control objectives, such as frequency control or generator protection can be integrated in the supervisory programs of the dedicated microprocessor.

1. Introduction :

Automatic voltage regulation (AVR) and reactive power compensation at the terminals of an electrical-power generating unit is normally achieved through the excitation system of the unit. The excitation system of a generating unit plays an important role in the satisfactory operation of the unit.(1) . It affects the stability limits under both transient and steady-state conditions. Quick response excitation systems raise stability limits, improve the quality of electric power service by reducing the voltage disturbance(2).

Accrdingly, recent developments have resulted in the application of thyristor-type excitation systems controlled by digital computers in real-time mode. Digital-controlled AVR'S provide many advantages including economy, easy maintenance, excellent response characteristics and compactness.(3) .

the main objectives of this research work is to develop a microprocessor-controlled set-up to study and investigate the performance of the generating unit under different loading conditions and to highlight the application-suitability of microprocessors in this field of engineering.

2. Sought set-up control scheme :

The sought set-up control scheme is schematically shown in Fig. (1). The terminal voltage is stepped down , fed to the low-pass filter (to filter the fundamental harmonic only), and the filtered output is fed to the microprocessor application trainer MAT-385 which is available in the laboratory. The microprocessor application trainer MAT-385 consists of analog-to-digital converter, micrprocessor type 8085 and digital-to-analog converter. The function of the microprocessor is to calculate the average value of a half-cycle of the terminal voltage to compare it with a reference value and to send a suitable control signal to adjust the required excitation through the controlled rectifier.

Two simple controlagorithas have been developed to supervise the automatic operation of the proposed system and are given in Figures (2,3). The procedure of the first algorithm of Fig. (2) is based on an increment/decrement controller and is summarized as follows:

1. Take samples of the terminal voltage over a half cycle.
2. Put the digit 1 zed samples in a table, and obtain the average.
3. Compare the average value with a reference stored value.
4. As a result of comparison, adjust the firing angle of the thyristor to reach the permissible error of the terminal controlled voltage.

The procedure of the second algorithm of Fig. (3) is based on a proportional-like controller and is summarized as follows :

1. Specify the maximum firing signal V_{max}.
2. Sample the terminal voltage over a half cycle.
3. Sum the digitalized voltage samples.
4. Compute $K.V_{av}$.
5. Compute the firing signal $V(\ ) = V_{max} - K.V_{av}$.
6. Send V ( ) to the controlled rectifier to control its output.

3. Experimental investigations and results discussions :

Two supervisory programs based on the flowcharts of Figs. (2,3) have been coded and have been used in a complete excitation control system on an isolated synchronous generator driven by a separately excited dc. motor. Tests were conducted for different types of loads (resistive and inductive). Some of the obtained results are to be discussed.

Under the increment/decrement supervisory program, Figs. (4,5) illustrate the relation between the generator terminal voltage and the load current (resistive and inductive) for controlled and fixed excitation. Whereas, Figs. (6,7) are depicting the same performance under the proportional-like supervisory program.

Conclusively, the first algorithm keeps the terminal voltage within acceptable band (+ 0.027 p.u.). The band can be narrowed further if the step size of the analog-to-digital and digital-to-analog converters is reduced.

The scheme of the first algorithm is convenient for study-state operation mode. But in the case of sudden load changes, the time required to maintain the terminal voltage at the desired band, increases as the magnitude of the sudden load increases. The speed can be increased by comparing the terminal voltage as well as its deviation with specified values and accordingly a command signal can put the terminal voltage to the desired band area.

The algorithm can be integrated to provide threephase short circuit protection by comparing the average value of the terminal voltage by a small value of reference voltage and accordingly send a command order to the circuit breaker to isolate the generating unit.

The second algorithm provides satisfactory study state operation by keeping the terminal voltage within acceptable limits. Its contribution for sudden load changes is superior to that of the first algorithm because the controller output in this algorithm is directly proportional to the magnitude of the voltage deviation and is not following the increment/decrement mode used in the first algorithm. The protection facility available in the first algorithm can be implemented in this algorithm because the two algorithm use the average value of the terminal voltage in deciding for the command.

4. Conclusion :

A developed microprocessor-controlled automatic voltage regulation of an electrical generating unit has been implemented. Supervisory programs have been coded and the computational part of them is basedon the evaluation of the average-value of the terminal voltage. The average value is compared with a reference to get an error. According to the error, the firing angle of the thyristorized excitation system is adjusted unit the terminal voltage returns inside the specified band.

The developed build-up of the control system and the supervisory procedures are simple, accurate and have fast response characteristics. Additional control and protection facilities may be integrated within the dedicated microprocessor.

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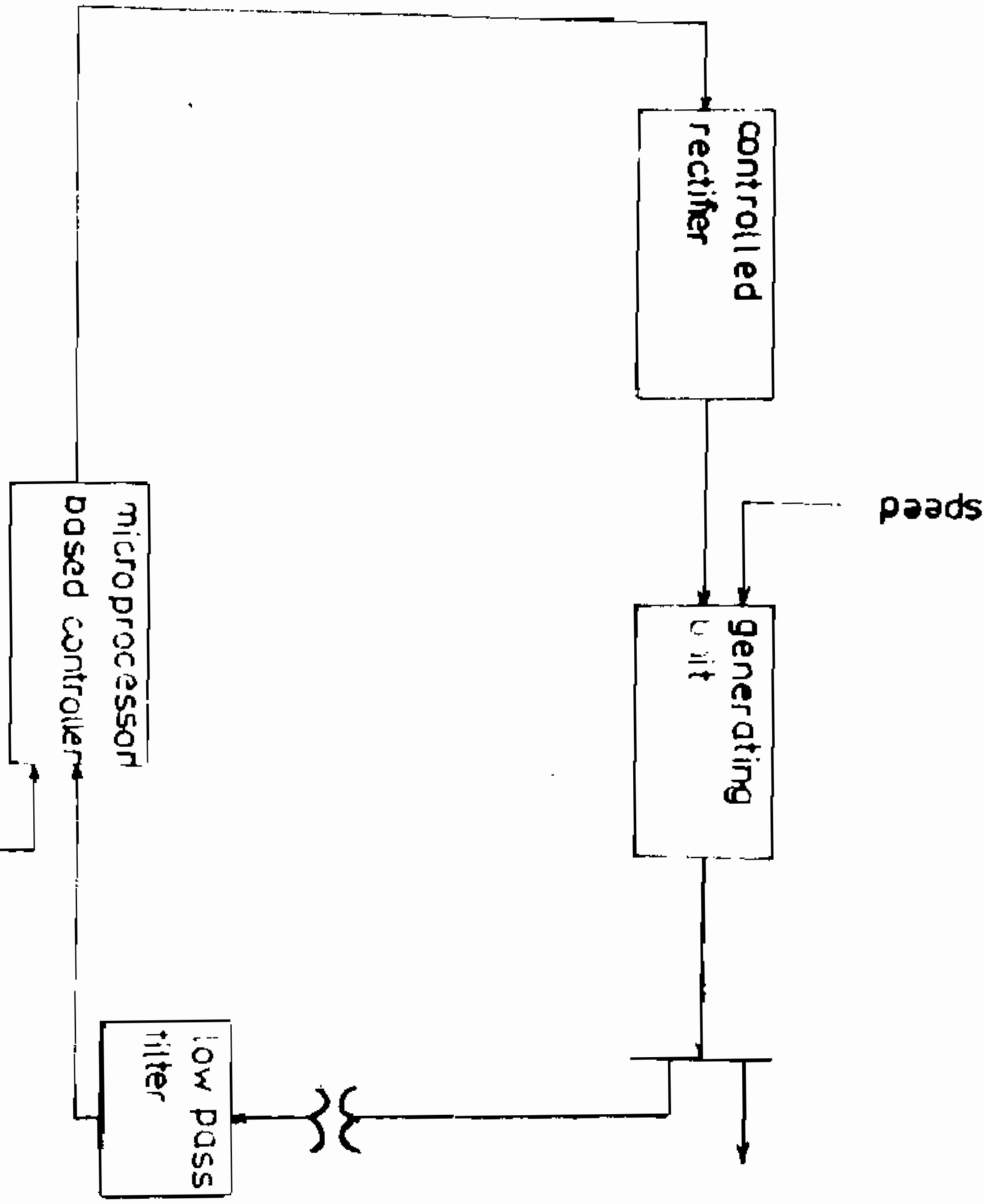


Fig. 1: block diagram of the excitation controller

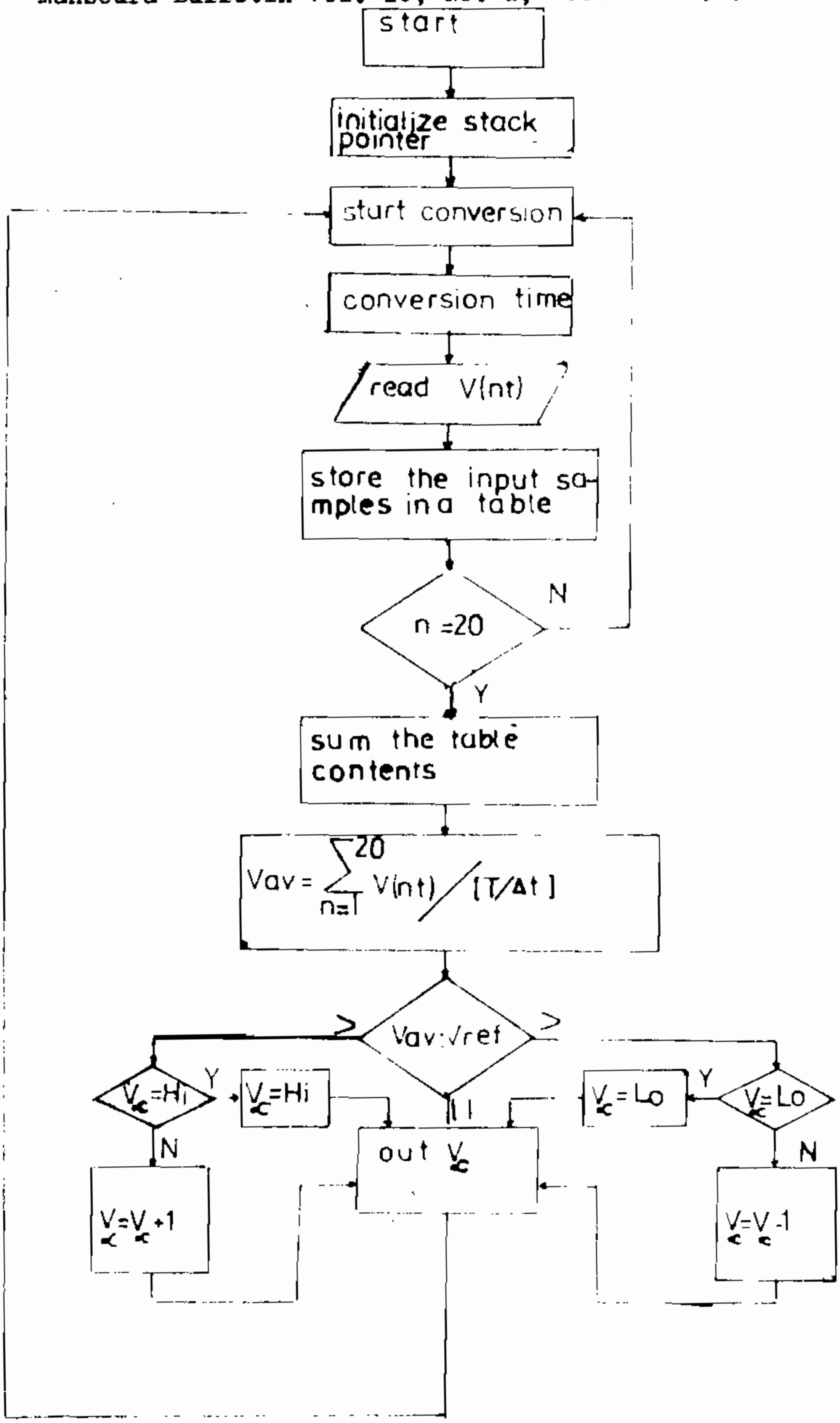
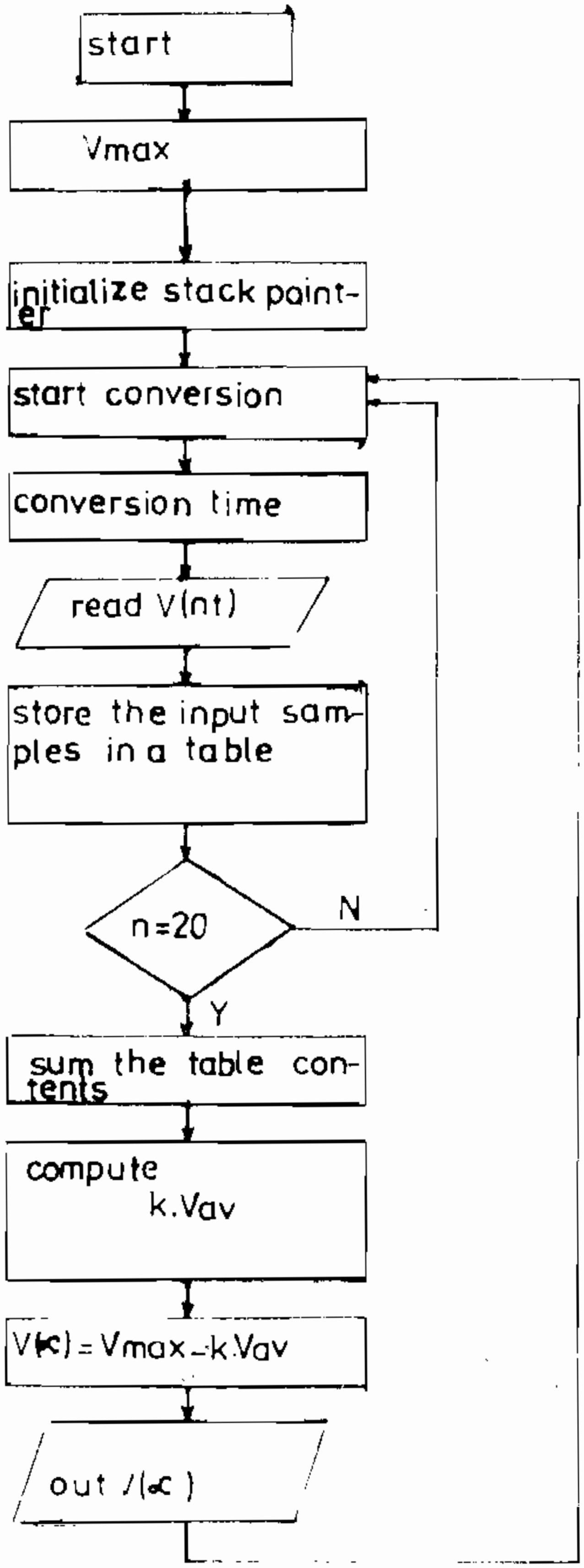


Fig (2): flowchart of the first excitation control algorrithm



Fig(3) : flowchart of the second excitation control algorithm

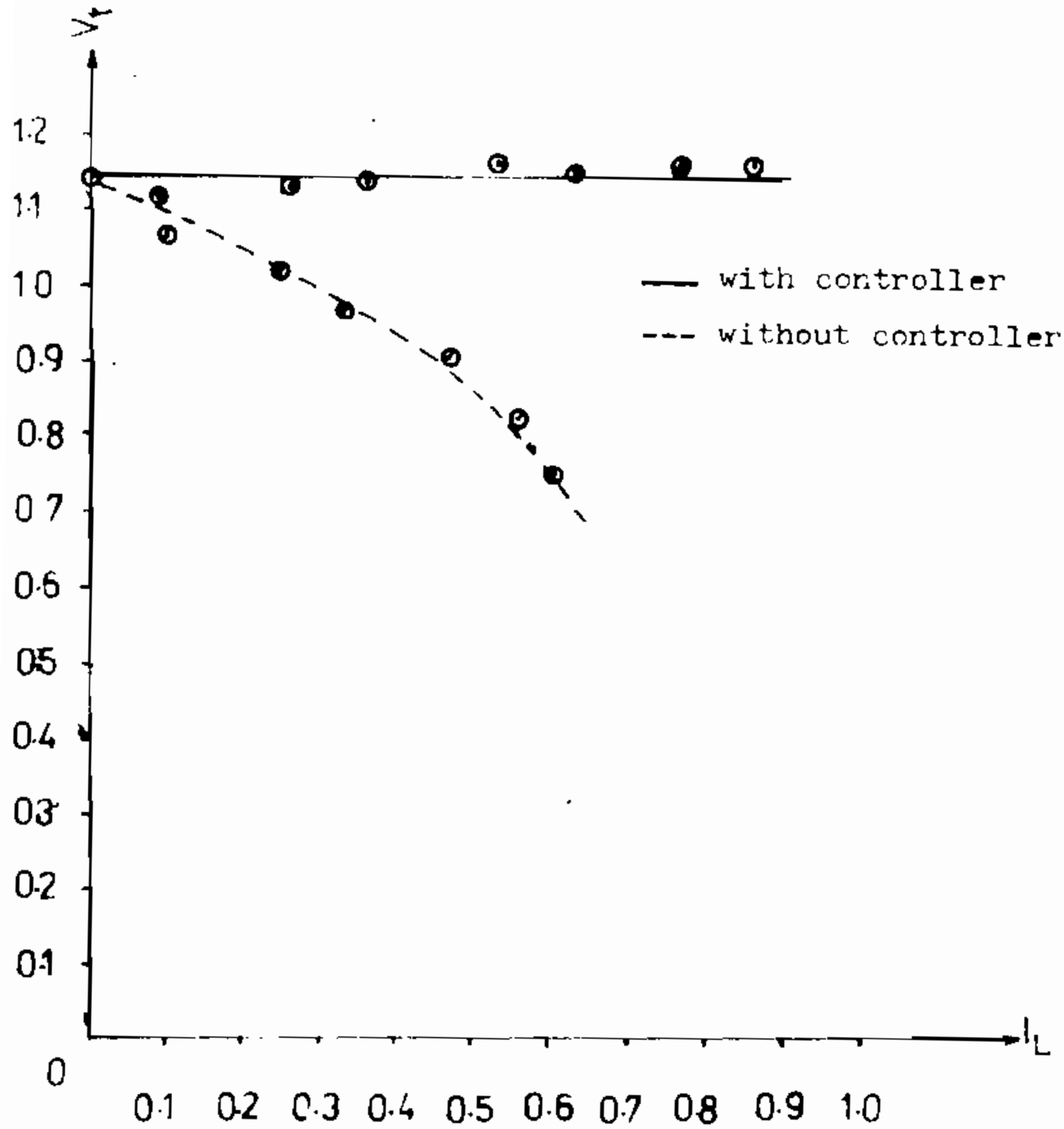


Fig (4) : terminal voltage/resistive load current relation

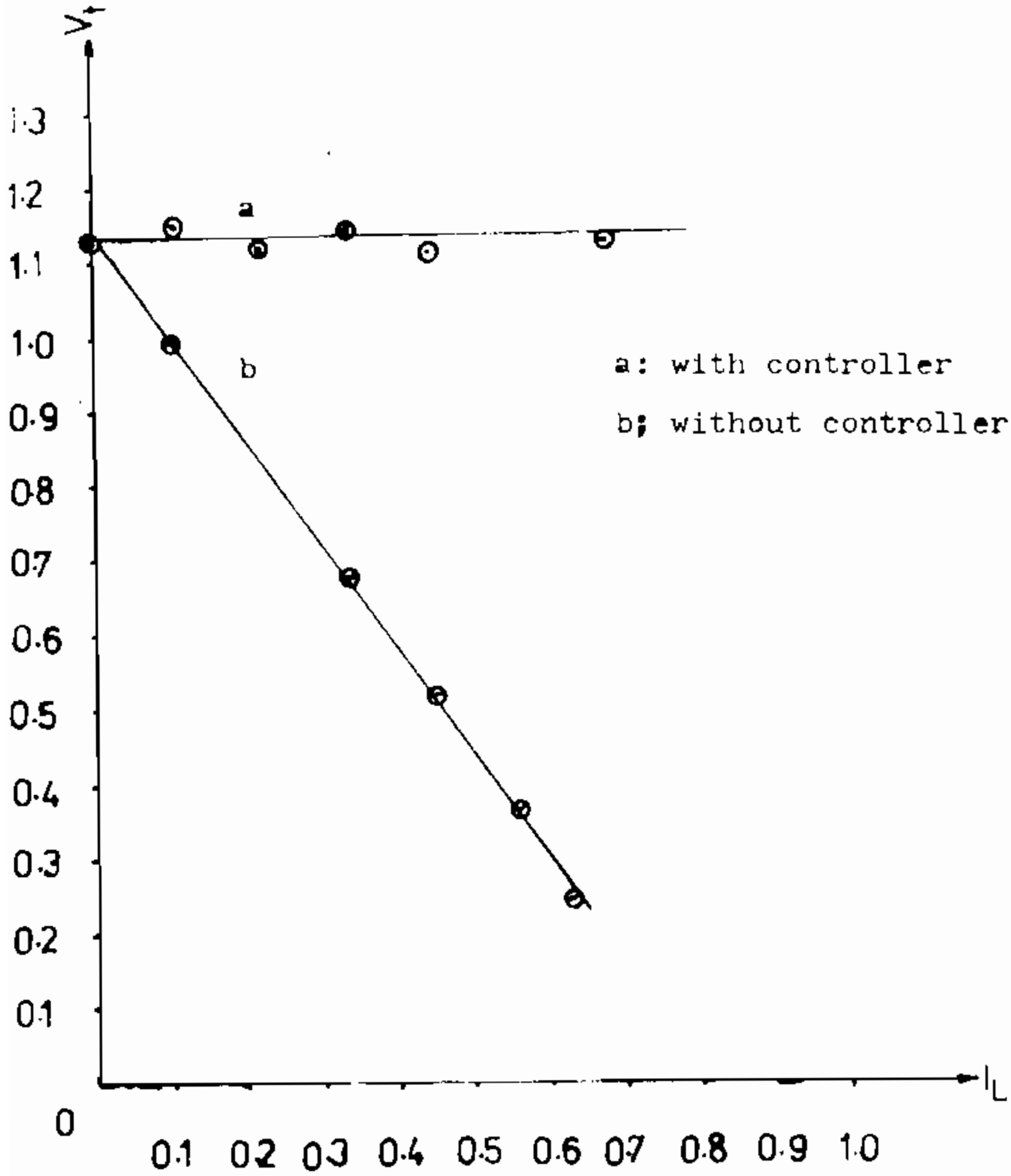


Fig (5) : terminal voltage/inductive load current relation

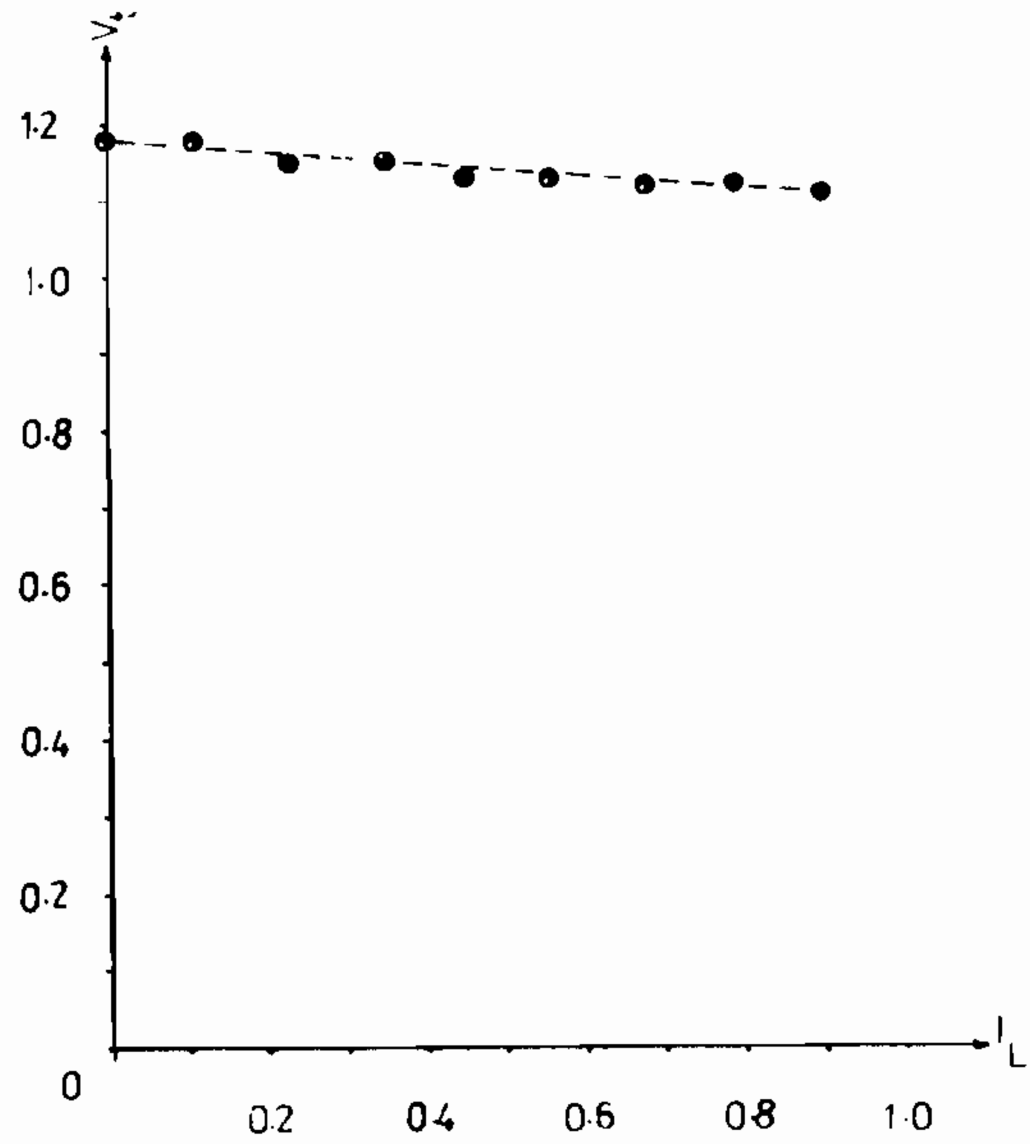


Fig. (6) : terminal voltage/resistive load current relation

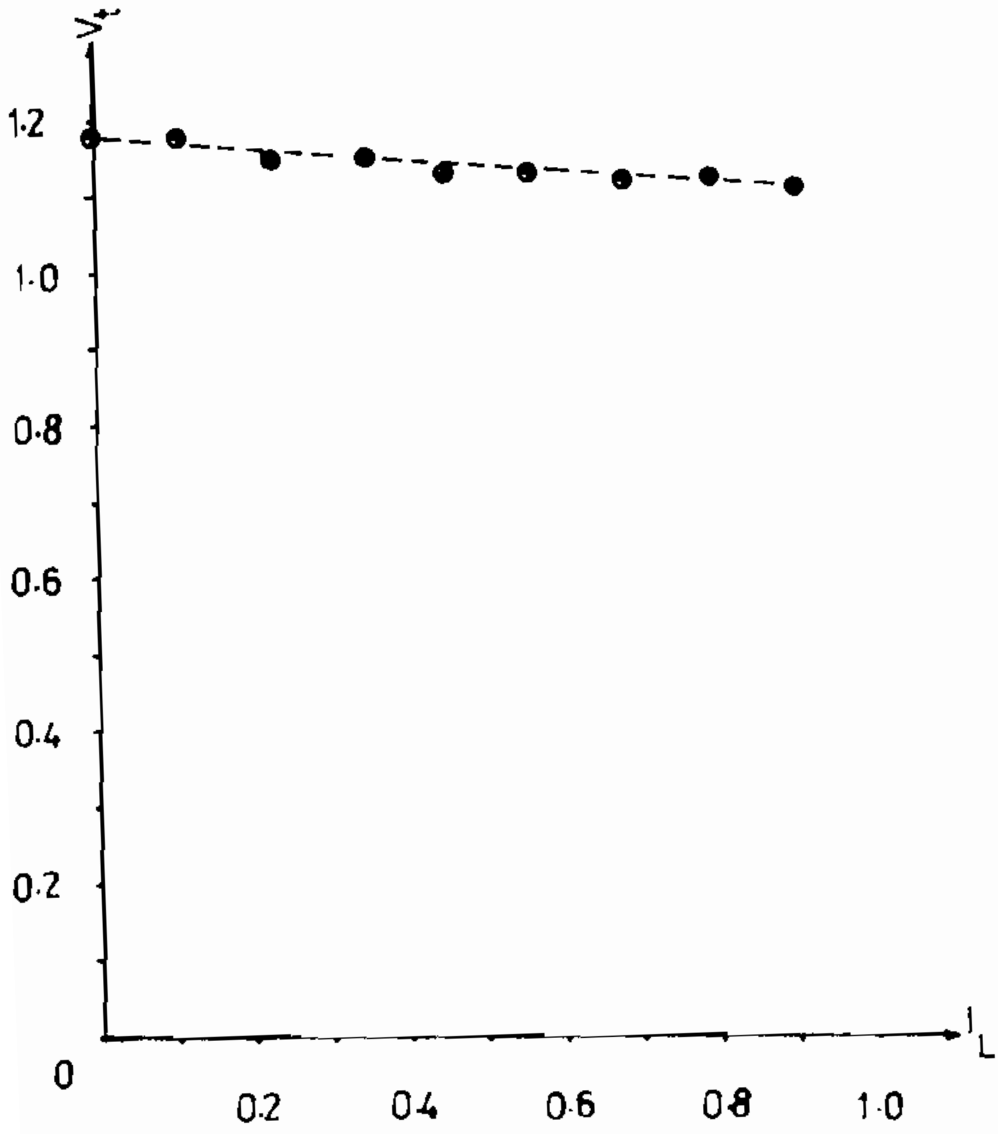


Fig (7) : terminal voltage/inductive load current