SCADA BASED POWER SYSTEM CONTROL

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ABSTRACT

Computerised supervisory control systems have been in operation in many countries for the past 10 to 15 years. The systems performance requirements are influenced by an arena of rapidly advancing technologies and a highly competitive business environment. There is multitasking of the use of microprocessors in power system control. This paper concerns four critical applications of the use of SCADA, system protection, metering, high-speed data exchange and distribution network automation. Specific information is given concerning system hardware. The advantages of the use of SCADA are explained and discussed. The detail of a power system under study is presented and commented on.

1 INTRODUCTION

The SCADA system is a general hardware and software concept providing a flexible set of functions. The actual use of the SCADA system is specified by parameters defined in the database. This brings down costs, increases system reliability through its well-proven design, and makes project development and implementation safe. Different kinds of measured values include voltage levels, active and reactive power flow, tap changer positions and other functions. These are collected by the control system and represent the momentary state of the measuring point. Usually these momentary values are treated and compared with measured values within the control system. This means that normalisation is required before the values are stored in the database. These measured values are generally scaled into engineering format before being presented or used in the application programme. The front-end computers do the scaling function and the results are stored in the database. The scanning of metered values is done either cyclically or on change of value. The desired target is to protect the elements of the network, to minimise data flow error to the lower limit and to prevent any damage to the power system

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equipment. Consequently the efficiency of the system distribution is increased and the reliability of the system is improved [1][2].

The overall control system to be implemented on the Cairo Metro Network (CMN) is referred to as an integrated distribution control system (IDCS), since it combines two systems, SCADA and local control. This necessitates front-end computers, a wide area network (WAN), and a control system linked to the electric power system [3].

2 CONTROL FUNCTIONS

An important class of functions are those which affect the power system. These control functions may be grouped into four subclasses.

- Individual device control
- Control messages
- Sequential control schemes
- Automatic control schemes

The individual device control stands for the basic command that can be directed towards the power system. On / off commands and start / stop for different pieces of electrical equipment.

Transmission of control messages to the regulating equipment represents a slightly more advanced control function. This concerns the raise / lower regulation and the set point of regulation. This means that supervision of the local equipment is required.

Sequential control includes the suitable security checks and time delays. Start up of illumination and heating equipment and the restoration and alteration of substation utilisation are examples of the sequential control concept.

Automatic control schemes enable the pre-made system to obtain a certain specific output, such as power or frequency. This requires a configuration such as a feed back system or the use of a certain controller.

3 SCADA IN THE POWER DISTRIBUTION SYSTEM

The SCADA system in IDCs will be discussed in four phases.

- Overview
- Communication
- Control system design
- Interface design

The overview includes the main electrical equipment, such as transformers, switchgear, incoming and outgoing feeders and all metering and protection devices. The LAN which connects the control centre and the field equipment is the means of transmitting messages to the regulating equipment which govern the electrical parameters such as voltage, current and temperature of the equipment.

SCADA in IDCs will be capable of doing the following functions:

- Load control, voltage / current control, distribution automation and operation, and the management of the desired operation;
- Co-ordination of the operation of the sub-station distribution system with the bulk power system;
- Access to real time system data;
- Switching of sub-station and feeder devices such as load tap changing transformer, breaker, regulator, switches and capacitors;
- Maintain the real power, reactive power and voltage level of all three phases of the power system;
- Communicate equipment and switch status information to the power system operator;
- Aid the operator during normal and emergency operations, improve system reliability, decrease outage times, optimise the performance of the distribution system and prevent the overloading of the equipment;
- Implement flexible control systems and alternative control strategies.

4 DESIGN CONSIDERATION

The design of the IDCs blends in well with the typical bulk power communication and control hierarchy employed in generation and transmission SCADA control.

The top level consists of the power system control centre, which co-ordinates the transmittable thermal generation of the sub-station. The block diagram of the various pieces of equipment related to the communication link of the control centre is as shown in Fig. (1).

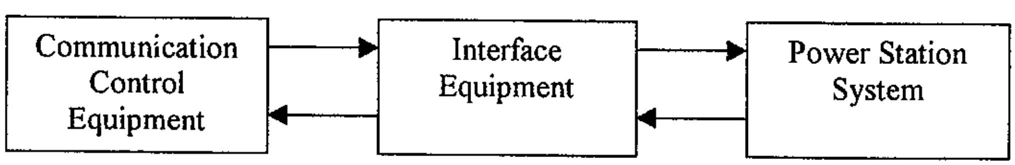

Fig. (1) - Communication Link of IDCs

The power system control centre in turn co-ordinates with five area SCADA transmission control centres, considered as the second level of control, as shown in Fig. (2).

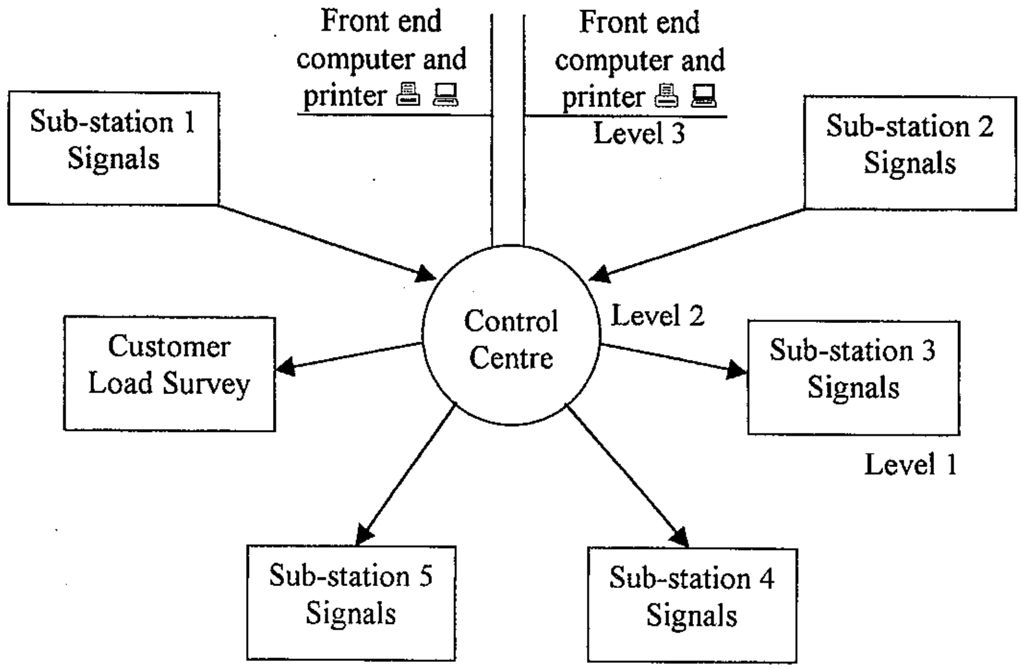

Fig. (2) - Power Control Centre and SCADA Control

The third level in the hierarchy consists of the communication and control centre located in each substation. The computer configuration is a dual system, one is a master and the other is a hot stand-by considered as a slave.

The fourth level is at the distribution sub-station, which consists of a programmable logic controller (PLC), sensors and relays, which automate the sub-station in a typical SCADA fashion.

Control signals are initiated at the control centre and sent to the sub-station for execution. Data sensed at the sub-station through devices such as potential and current transformers are sent back to the control centre. Information such as breaker status, tap settings on the transformer, voltage values, active power, reactive power load condition is then stored in the central database.

5 HARDWARE OVERVIEW

The control centre communications from the SCADA system consist mainly of non-standard items such as load survey, load control devices and the distribution feeder remotes as shown in Fig. (3).

The data, which is received in the control centre, is processed before the computer sends a command to the RTU. Using microprocessor intelligence and local memory it buffers the incoming messages and transmits the outage response. It is also responsible for error checking and hand shaking to ensure the integrity of the bi-directional communication. The line buffer is another microprocessor-based sub-system at the control centre. It has direct memory access into the SCADA database and bi-directional serial port, through the telephone modem, to the RTU.

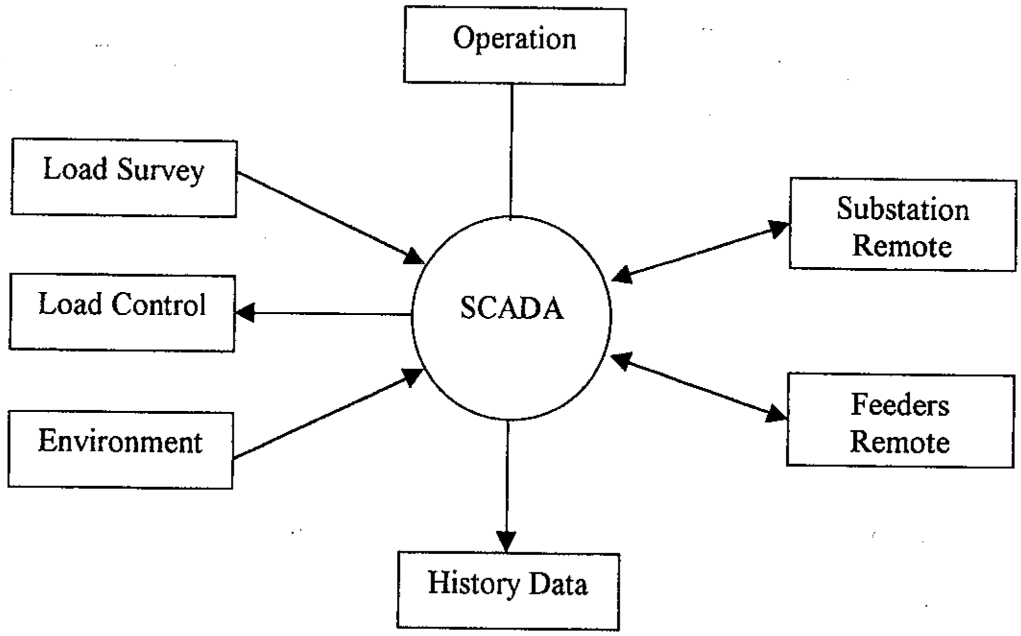

Fig. (3) - Communication Control Centre Elements

6 SOFTWARE DESIGN

The software design of the communication and control system, considered broadly, includes a real time and hierarchical database structure. The communication and control system software includes standard and customised functions. The standard software comprises the basic SCADA functions, load control, and meter reading intelligence. The special software is confined to the control strategy application program and the necessary interfaces between software sub-systems. The basic SCADA configuration is illustrated in Fig. (4).

The sub-station controller is a computer system designed to operate in the sub-station environment. It is composed of a hardware module and software applications, which generally fall into one of three functional elements, as follows:

Data Processing Applications (DPAs)
These software applications provide the various users with access to the data of the sub-station controller. They are used to provide instruction and programming to the sub-station controller.

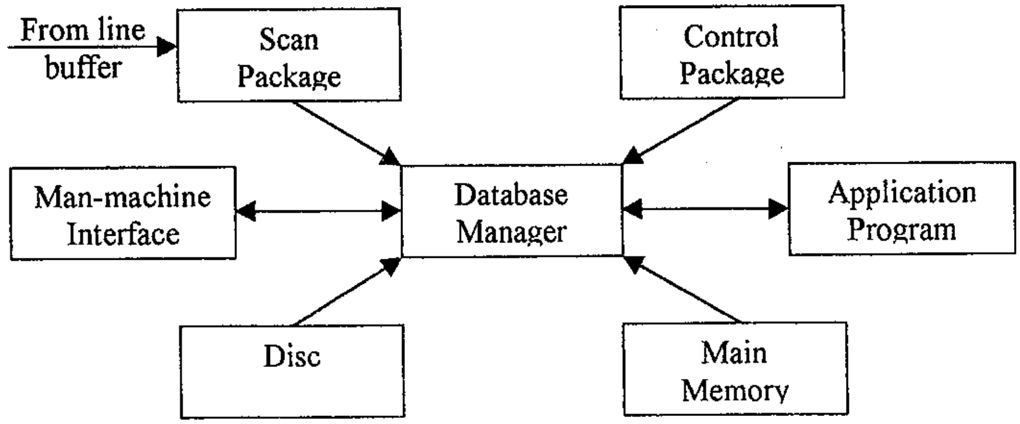

Fig. (4) - Software and Architecture of the Communication and Control System

Data Collection Applications (DCAs)

These software applications provide the access to other systems and components that contain data elements necessary for the sub-station controller to perform its function.

Control Database

The key to the sub-station controller is the database function. In this facility all data resides in a single location, whether from DPAs, DCAs or from the sub-station controller itself. This database acts as a file server and provides data to the various data concentrators and data processing applications.

7 THE SIMULATION RESULTS

The results obtained from the sub-station are as follows:

Input voltage	= 20KV
Output voltage	= 0.750KV
Average dc voltage	= 750 – 550 V dc
Rated current / motor car	= 156 amps / motor

The simulation results of harmonic current and individual current for each motor are shown in Figs. (5), (6) and (7).

8 CONCLUSION

In this paper, SCADA documentation and technology regarding the design of a power distribution control system have been presented. The system configuration and complexities are shown in the results. The communication links, hardware and software of computers have been discussed and commented on.

9 REFERENCES

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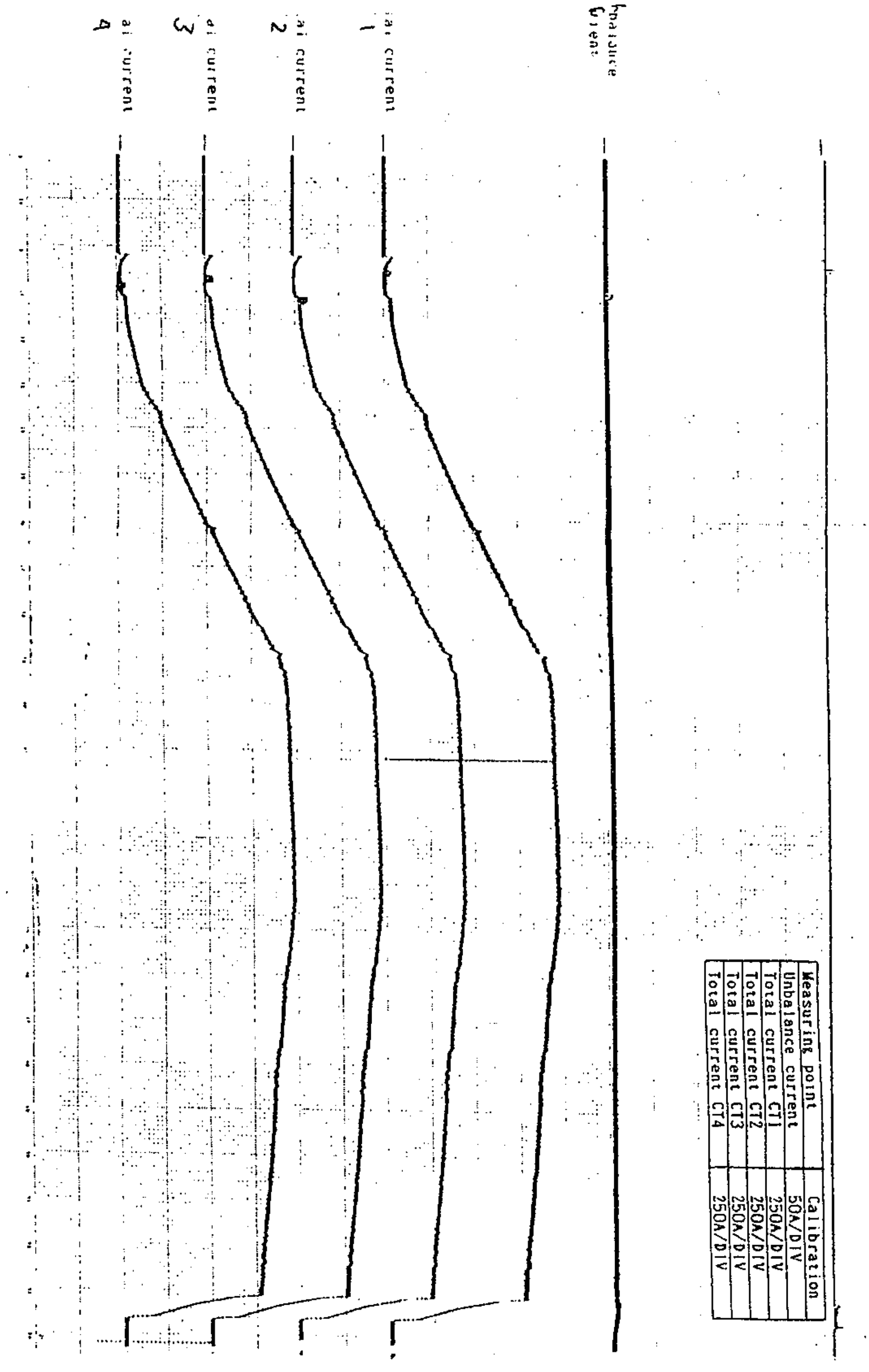

Fig. (5) - Current / Motor = 200 Amperes

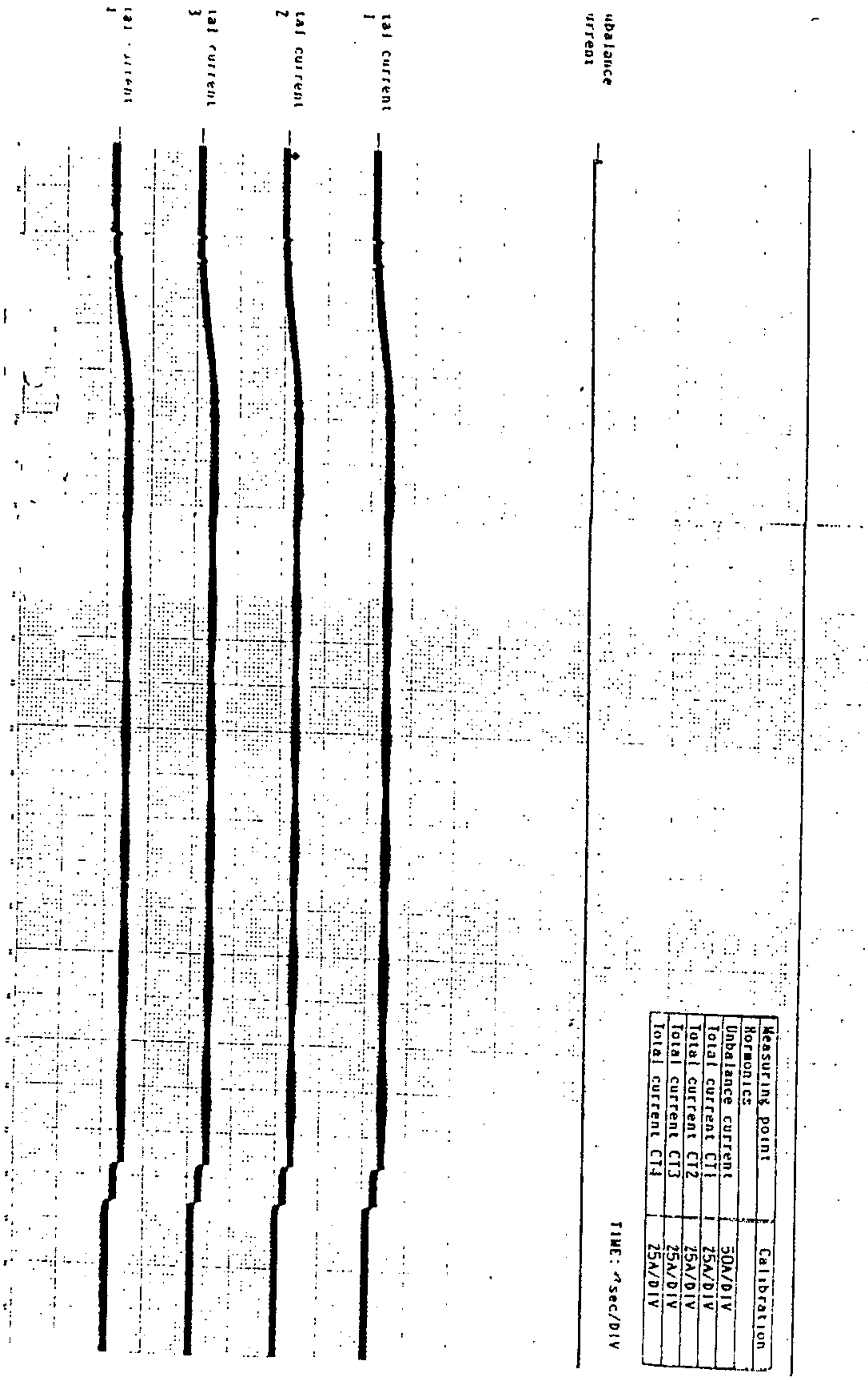

Fig. (6) Current / Motor = 12 Amperes

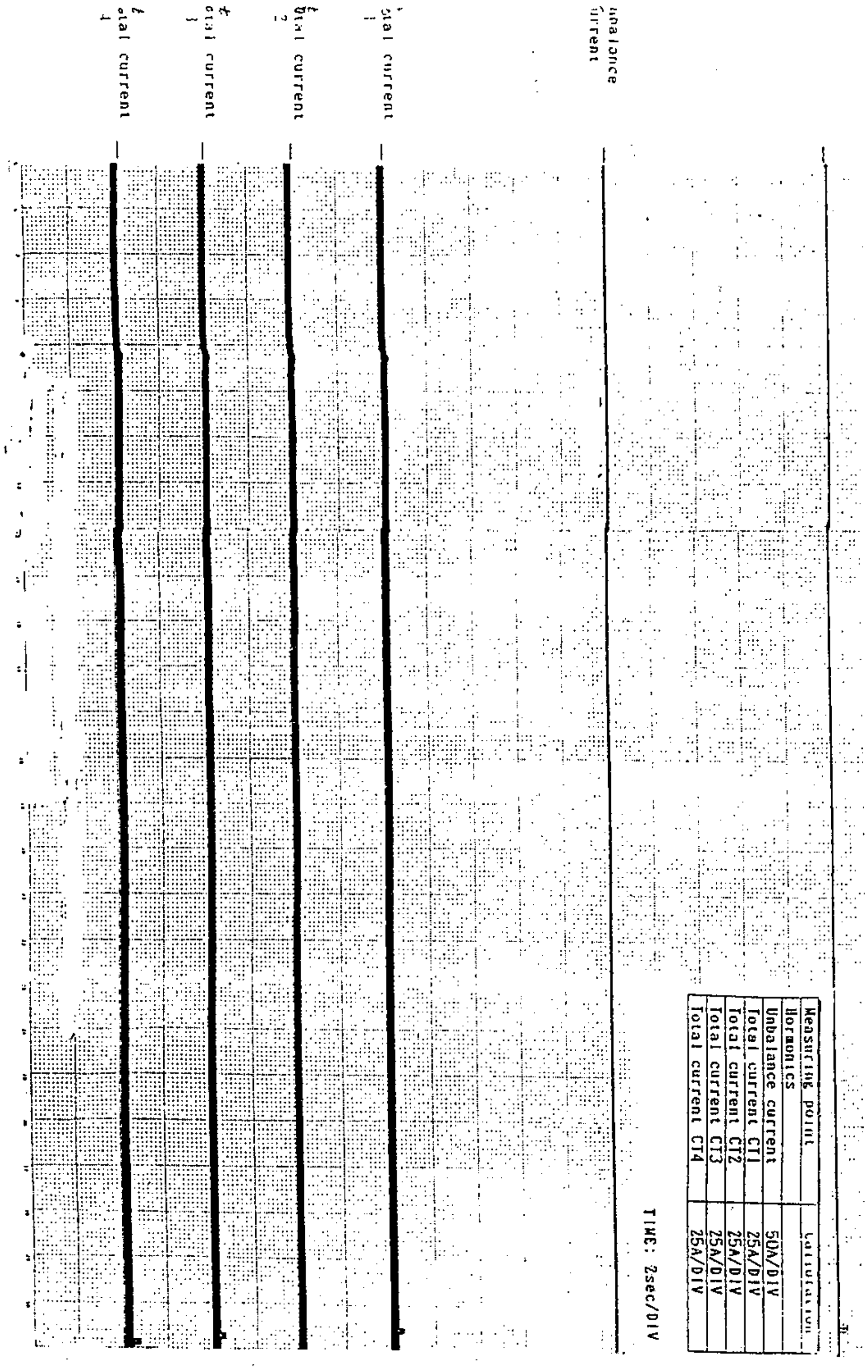

Fig. (7) - Current / Motor = 2.5 Amperes

تحكم نظام القوى بواسطة الطرق الرقمية

الملخص :

إن أنظمة التحكم والمراقبة بواسطة الخواسب – أصبح الآن – مستخدمه في كثير من البلدان منذ مايقارب ١٠–١٥ عاماً . إن خصائص متطلبات هذه الأنظمة تتأثر ولحد كبير بالتقدم التكنولوجى وبالظروف البيئية المحيطة . ويجد عدداً من الأهداف من إستخدام المعالجات الرقمية في التحكم فى أنظمة القوى . وهذا البحث معنى بالدرجة الأولى لأربعة تطبيقات هامة لهذا النظام – حماية النظام والقياسات وسرعة تبادل البيانات وأنظمة الأتمته فى التوزيع . ويأخذ فى الحسبان المعلومات النوعية عند بناء النظام التقنى . إن الميزة من إستخدام هذا النظام قد تم شرحها ومناقشتها ، وتم تفصيل النظام – تحت الدراسة والتعليق عليه .