Distributed Microprocessor Controllers using Optic Fiber Network

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Abstract

This work continues a previous project devoted to the supervision and control of electric motors in large industrial plants. This project consists in a set of microcontroller boards that communicate with a Global Control Card (GCC). The transmission of messages in the system is done using a optic fiber network.
The GCC can be linked to a supervisory computer by a serial communication channel. A program processes the system schematics and authomatically generates the configuration files. This project has been realised in collaboration with INABENSA (ABENGOA) and funded by the ATICA programme.

1. Introduction

Usually, the control of the diverse electromechanical elements of an industrial plant is centralized in control modules composed by a series of carriages. In these, contact makers, timers, relays and other electromechanical devices, and a great quantity of electric wires implement the logic operation sequence in every electromechanical element.
This project substitutes the electromechanical system control by a digital electronic system implemented in a set of microprocessor cards, and the wired logic by some logic equations included in EEPROMs. It also includes two software programs, one for remote supervision and control of the system state (SCP) and another for the automatic generation of logic equations from electric schematic (ASC).
Figure 1 shows the substitution of the wiring and supervision tasks by an automatic configuration and remote supervision tasks, respectively.

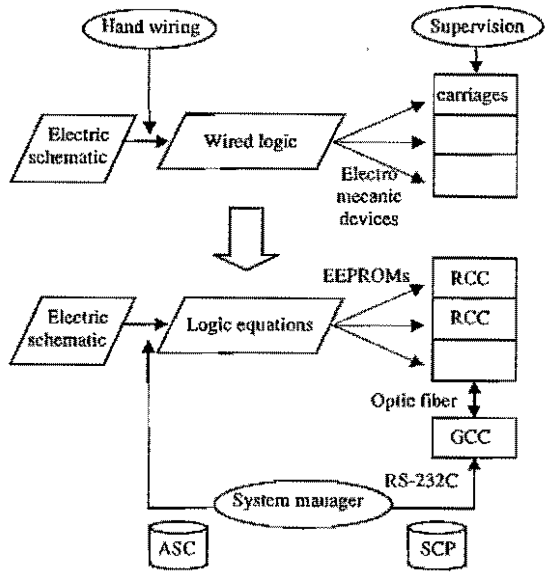

Figure 1: Changes in the electric system.

2. System architecture

The control and supervision system is composed by the following elements (figure 1).

- A set of microcontroller remote control cards (RCCs).
- One microcontroller global control card (GCC).
- Configuration Program and supervision (SCP).
- Automatic generation of logical equations program (ASC).

The group constituted by the bank of remote cards (RCCs) and the global one (GCC) determines a system able to implement and autonomous system control.

GCC sends logical equations to every RCC, and the last one stores them in EEPROM. Card communication is carried out through a connection of low cost plastic optic fiber, and it is controlled by GCC. So, at any time, GCC stores the real configuration and system state. Besides, a RS232C communication channel in the GCC is allowed. Supervision and Control Program (SCP) communicates with GCC using this second channel and shows to system manager the system state and configuration in a easy and suitable framework .
Another additional functionality of the PC is to run the Automatic Schematic Compiler (ASC). This one obtains the logic equations used by the microcontroller cards.

3. Control cards

Every RCC is responsible to control the local system. They use the 68HC11E1 microcontroller to run the control program, stored in an external EPROM. The behavior of the system is described as logic equations, stored in the internal EEPROM of every microcontroller. Once the RCC are configured, they store their configuration in EEPROM, so that, reconfiguration is no longer need. After power up, RCCs work autonomously.
An RCC has 8 digital input circuits to obtain local information (alarms, relays ...) and 8 output circuits to activate diverse elements (contaet makers, lights, relays, ...), (figure 2). The output signals are continuously evaluated from input signals of the system and internal variables (timers and other cards variables). In case of a local variable affects another RCC, the change in this one is communicated via optic fiber link.

There is a GCC that controls the overal system, and carries out the following tasks:

- To store the most representative variables in the system.
- To control the optic fiber link communication.
- To configure the system initially, sending the logical equations to RCCs.
- To communicate with PC.

RCC-RCC and GCC-RCC communications are possible using a low cost optic link. So, Hewllet-Packard HFBR-1521 transmitters and HFBR-2522 receivers have been included, working at λ=660 nm. (red light).
THE Longest link can be implemented using plastic optic fiber is 50 mts., enough for most applications. The acceptable maximum speed is 1 MBd. In this application a 125 KBd communication is used, enough for the required data flow.
The system configuration is Token-bus, using a simplified version of the standard protocol IEEE 802.5. To get the Token-bus configuration, a opto-electronic hub card has been used (figure 4). One control card CC (RCC or GCC) hold the Token, being enabled to send any message to another CC. The message is sent through the hub card to every CC, but only the one specified in the message will process it. Finally, the token is sent to the next CC to enable its communication. Anyway, the GCC is the one that keeps the control of this communieation, distributing the Token optimally.
GCC has an additional electronic expansion card. This one has an external RAM memory and a RS232C communication module. Therefore, GCC is the only control card able to link with a PC. External RAM memory stores all variables that represent the system state, (figure 2).

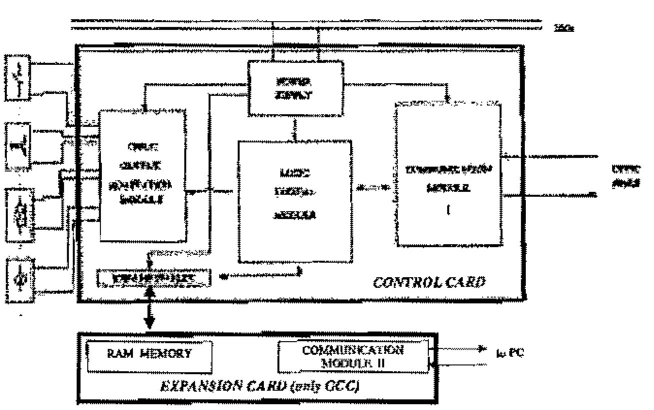

Figure2: Block diagram of a CC.

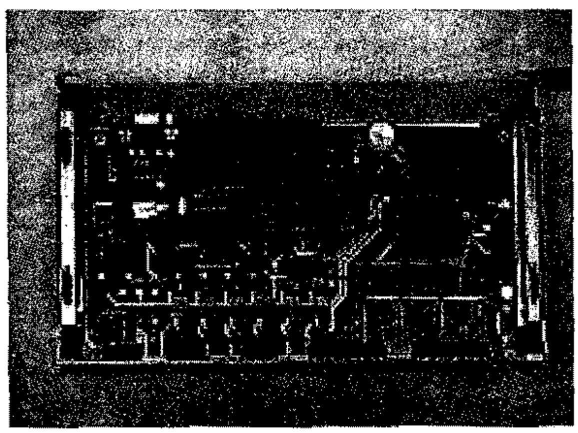

Figure3: Global Control Card.

4. Supervision and control program (SCP)

In order to supervise the state of the system, a supervisory control program (SCP) has been designed. C++ Builder Tool has been used as a development framework.

This graphical user interface displays all carriages of the system in a PC screen (see figure 5). It is very important that the system manager can quickly identify every carriage by its position and size. Therefore a scaling representation of the real system is presented, including the external signals (luminous indicator, buttons, ...). A hardware description language to define this kind of system has been developed. An ASCII file contains the description of the system.

Selecting one carriage in the main window an auxiliary one is opened (figure 6) deseribing the local logic circuit using contactor makers, switches, lights, external iuputs and output signals, etc.... A simple three-phase power circuit description is also included.

The system state information is periodically collected by the GCC and sent to the SCP. The actual state of every element in the auxiliary window is real-time updated.

The operator is able to control remotely every carriage selecting switches directly from the screen. Besides this functionality, the SCP has other two functions. The first one is initially configuring the whole system. It reads the configuration file *"master.dat"* that contains all logic equations of the system and transfers it to the GCC. The second one is to indicate to the GCC how many RCCs are in the system.

5. Automatic Schematic Compiler (ASC)

Another feature of the system is the automatic generation of logic equations files (lgc format) from AutoCad graphics. The AutoCad graphics show the electrical schematic of the local system. That schematic describes the elements and their connections. The compiler analyzes it and obtains the logic equations represented by the schematic. With this set of equations the compiler generates a logic equation file. A subsequent treatment transform the lgc file in a binary file for the card microprocessor card, (figure 7).

The compiler has been designed and implemented using the Builder C++ Tool and is fully compatible with Windows 95.

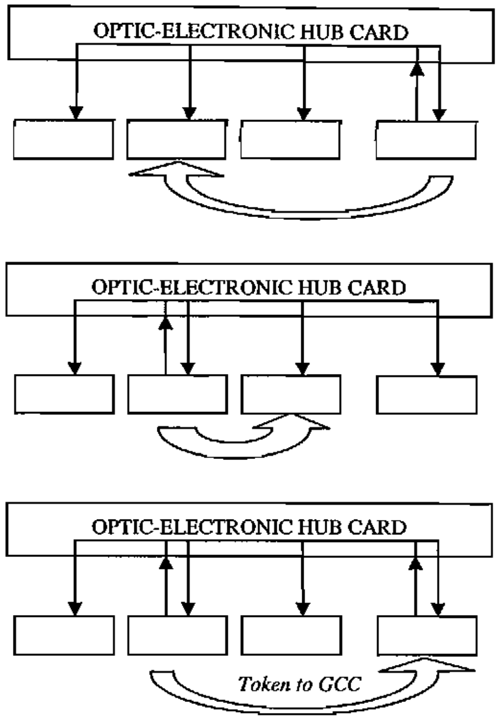

Figure 4: Token-bus configuration.

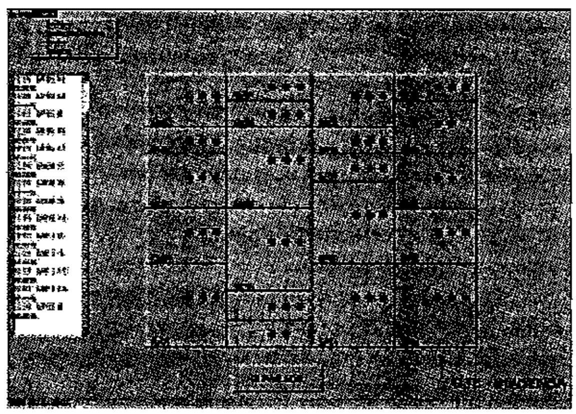

Figure 5: Carriages view (SCP).

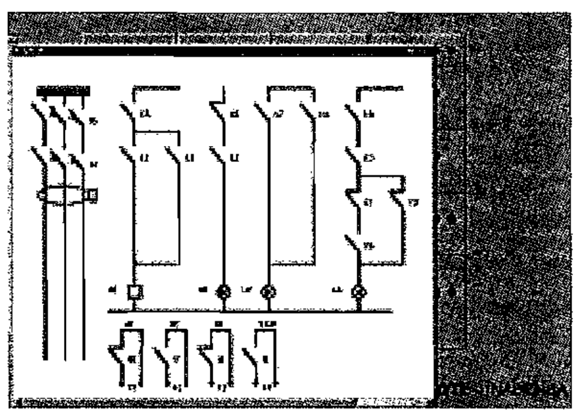

Figure 6: Schematic of carriage view (SCP).

6. Conclusions

The control system presented gets the following improvements regarding the traditional method of electromechanical control centre:

a) It removes most of the electric wired logic in each carriage.

b) An optic fiber channel that is immune to noise allows the communication between control cards.

c) The configurability of the system increases, because any change is carried out via software, and no hardware modification is needed.

d) All CCs are implemented using the same electronic circuits. Its specific behaviour is initially programmed, therefore the cost of each carriage is decreased.

e) The supervision and control of the system, that did not exists in the electric implementation of the control centre, can be carried out using a monitoring system running on PC.

Some manufacturers use PLCs to implement the control system. In many applications, this is a very expensive and unnecessary method. However, our microcontroller based implementation offers to system manager a very simple method to control the processes and is opened to others alternative configurations. This control system may be easily customised and the cost is divided by ten.
In summary, the main advantages of our approach is that digital electronic circuits in the system increase the functionality of the system (programmability and monitoring). The use of a optic fiber link decreases the wiring effort when implementing the control centre, and implements a noise free communication network. All this advantages increase the performance of the system and drastically reduce its manufacturing cost.

7. References

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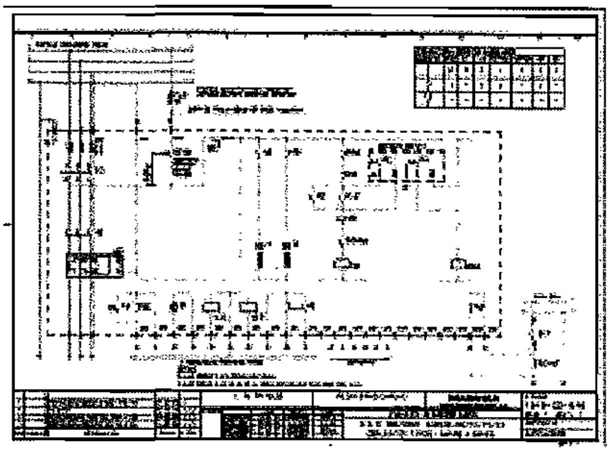

Electric schematic

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/F1=89*((KM3*RT1N)+(KM1*RT2N)+KM2)

 /CARRO1 (TARJETA 6)
K1=15N  /RT1
K2=16N  /RT2

O2=K3
/O2=KM1
O3=K4
/O3=KM2
O4=K5N
/O4=KM3
O5=K6N
/LR=O5
O6=K7
/LA=O6

K1>C0,K61
K2>C0,K62
K3<C0/K63
K4<C0/K64
K5<C0/K65
K6<C0/K66
K7<C0/K67
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lgc format file

Figure 7: Automatic generation of **lgc** format file.