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REGENERATION OF THE CABINET PASSIVATION SYSTEM DATA ACQUISITION PROCEDURE OF THE PUBLIC TRANSPORTATION SYSTEM

[1]M.C. Violeta Martínez Ramírez, [2]Ing. Iván Martínez López, [3]Ing. Oscar Uriel Morales Olguín, Ing. Josué Romero Teodoro, M. I. Alejandro Gil Vázquez, ([3])Ing.

[1]Instituto Tecnológico de Puebla
Tecnológico Nacional de México
Department of Systems and Computer Science
Av. Tecnológico # 420 Col. Maravillas Puebla Puebla Puebla CP 72220 México
violetmartinezr@gmail.com

[2]Instituto Tecnológico de Tláhuac
Tecnológico Nacional de México
Department of Electrical and Electronic Engineering
Estanislao Ramírez Av. # 301 Colonia Ampliación Selene C.P. 13430 Tláhuac CDMX

[3]Instituto Tecnológico de Tláhuac
Tecnológico Nacional de México
Department of Electrical and Electronic Engineering
Estanislao Ramírez Av. # 301 Colonia Ampliación Selene C.P. 13430 Tláhuac CDMX
uriel.warlike@gmail.com

[4]Instituto Tecnológico de Tláhuac
Tecnológico Nacional de México
Department of Electrical and Electronic Engineering
Estanislao Ramírez Av. # 301 Colonia Ampliación Selene C.P. 13430 Tláhuac CDMX
josue.romero.teo@outlook.com

[5]Instituto Tecnológico de Tláhuac
Tecnológico Nacional de México
Department of Systems and Computer Science
Estanislao Ramírez Av. # 301 Colonia Ampliación Selene C.P. 13430 Tláhuac CDMX
ing.gil@ittlahuac.edu.mx

SUMMARY

The present research and development work aims to implement a graphical user interface (GUI) using java programming language, to provide continuous control of the running of the trains of Line A of the Public Transport System (STC), in Automatic or Manual Controlled Driving mode, allowing the circulation of the trains in the following modes trains with short separation distances, and with full safety.

The system was developed considering the safety conditions, which are guaranteed by means of a permanent control and verification device, which generates a continuous transmission (track - train) of information in order to avoid under any circumstances that the train is in dangerous situations or close to them.

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This development, in addition to being low cost, has the necessary security locks so that a cabinet cannot be rearmed if it is not in passive state and if the personnel does not have the necessary credentials to perform this procedure. The solution obtained in the present work is integrated in the interface designed in java of the Collective Transport System allowing the access to the system in real time from any point where there is a computer connected to the designed program.

Key words: *Automatic Piloting, SACEM, Mass Transit System*

INTRODUCTION

The Mexico City Metro is a metropolitan train-type public transportation system that serves large areas of Mexico City and part of the State of . Its operation and exploitation is in charge of the decentralized public agency called Sistema de Transporte Colectivo.
Line A is the ninth line of the public transportation system network that runs through part of Mexico City and the State of Mexico from north to south. It has only 10 stations and a length of 17.19 km, of which 14.89 km are used for passenger service and the rest for maneuvers and maintenance. It is distinguished from the rest of the lines by having 6-car trains powered by catenary. For this reason it is also known as Metro Férreo or Metro Ligero.

Background

The SACEM (Sistema Automático de Conducción, Exploración, al Mantenimiento) is of French design and manufacture by INTERELEC in 1983. It was implemented in Mexico on the trains of lines A, B and 8 (between 1990 and 2000) [8].

It consists of an embedded computing system (based on FPGAs and microprocessors) and provided with a diagnostic system called SPY running on an Intel 486 laptop computer, with a 16-bit MS-DOS operating system [7].

According to [7], SPY generates real-time information on the operating status of the system, which is used by a trained technician to determine the origin of a fault, analyze the procedure leading to its correction, and schedule the corresponding preventive maintenance. The software communicates with SACEM through a guided medium, a specialized diagnostic port and protocol. SPY stores and displays on screen 74 parameters such as: type of gear, available gears, train speed, braking defects, location, vibrators, door opening permission, among others.

In 2010 SPY was updated, unlike the original, it runs on Windows XP and Vista, has a graphical interface based on LabView, can communicate wirelessly with SACEM and performs basic fault diagnostics. There is also a need for similar facilities for the maintenance of PA 135 systems (Chopper and JH).

Fault detection and diagnosis

The first formal schemes for fault detection date back to the 1970's (methodologies documented by Alan S. Willsky in 1976[7]). Fault detection is to determine whether the system is operating in a correct or incorrect state.
Fault diagnosis means that once the presence of a fault is detected, we proceed to specify what type of fault it is and how to repair it.

Current status of the subject

The P. A. driving mode is the one in which trains should normally run to ensure passenger comfort during service. Any degradation of the driving mode must be authorized by the P. C. C. C. or P. C. L. as the case may be.
The Passivation condition in a SACEM Automatic Pilot cabinet of Line A can be caused by any of the following causes:

1. Due to untimely power outage (micro-outage).
2. Due to software degradation.
3. Power supply failure.
4. Failure of any electronic card of the ATP or ATO modules.

When the Passivation condition arises, maintenance personnel are informed for timely intervention.

Problems to solve

The inventory and inspection of the active equipment within the operating scheme within the STC Line A was carried out, which allowed listing the difficulties to be solved with the construction of the monitoring program:

- Reduce downtime due to the absence of Autopilot information from a passive cabinet.
- To speed up the intervention of maintenance personnel in the rearming of the SACEM automatic piloting equipment cabinets.
- Report failures in the power supplies that feed the electronic equipment in the cabinet, so that maintenance personnel can solve the problem.

Overall objective

Regenerate the data acquisition procedure of the cabinet passivation system of the mass transit system by implementing a graphical interface to provide continuous monitoring of the running of the trains, Line A.

Justification

The increasing interruption of the SACEM automatic piloting sources has caused multiple problems in the conduction and maintenance of cabinets. Forcing the implementation of a constant monitoring and automatic reset design. For this purpose, a circuit will be developed electronic signal reception and a visual interface for monitoring and quick response to cabinet or source maintenance that directs the SACEM automatic piloting benefiting the STC.

DEVELOPMENT

Methodology

Object Oriented Programming (OOP).

OOP is based on the natural idea of the existence of a reality full of objects and that problem solving is done in terms of objects. In OOP, programs are defined in terms of classes of objects, objects that are entities that combine state, behavior and identity. OOP expresses a program as a set of these objects, which collaborate with each other to perform tasks (interaction, object communication through messages).

The main *features* of the OOP are:

- *Abstraction*. Select relevant characteristics within a set and identify common behaviors to define new types of entities in the real world. Abstraction is key in the process of object-oriented analysis and design.
- *Encapsulation*. A mechanism for hiding the internal details of an object from other objects.
- *Polymorphism*. Ability of a method to behave differently according to the class that implements it.
- *Inheritance*. Creates hierarchies in objects of a program. It allows inheriting the set of methods and attributes of a class without having to rewrite the code of that class.

The *advantages* of OOP:

- *Code reuse and extension*. An OOP program consists of independent modules, which can be reused in different programs and even extend the code, saving development time.

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• *Maintainability*. An OOP-based program that is subject to changes in external conditions (such as the definition of a new variable) will involve few program modifications.

• *Creation of complex systems.* It allows the creation of more complex systems capable of relating a system to the real world, as well the generation of graphical environments and construction of prototypes more quickly and easily.

OOP also has some *drawbacks*:

• *Performance*. Languages using the OOP paradigm have lower performance compared to other structured languages.

• *Long learning curves*. In making the transition to an object-oriented paradigm most programmers must learn to solve problems in terms of objects.

• *Determination of classes.* A class is a mold used to create new objects. In case the classes that were established are not possible to develop, it will be necessary to restructure the class hierarchy (Francisco Duran, 2006).

Java EE platform.

Java technology is both a programming language and a platform. The programming language is a high-level object-oriented programming language that has a particular syntax and style. A Java platform is a particular environment in which Java applications run (Francisco Duran, 2006).

What is Java Netbeans?

NetBeans is a free integrated development environment, made primarily for the Java programming language. It is a free and product with no usage restrictions. Sun MicroSystems founded the NetBeans open source project June 2000 and is the projects main sponsor.
The NetBeans IDE supports the development of all types of Java applications (J2SE, web, EJB and EJB).
mobile applications). Its features include an *Ant-based* project system, *version control and refactoring.*
Modularity. All IDE functions are provided by modules. Each module provides a well-defined function, such as Java support, editing, or version control system support.

Peripheral Interface Controller (PIC).

PICs are a family of microcontrollers developed and manufactured by Microchip Technologies Inc. which RISC technology and have special features in their internal architecture that vary depending on the PIC model. These devices are similar to a computer, since they have similar resources: they have program memory, RAM memory, data memory, input or output ports, timers and in some cases they have additional resources such as A/D converters, comparators, USART, I2C serial communication, among others.

The design of programs for PIC microcontrollers is accompanied by a previous study of the hardware design that will allow the project to work. for
PIC microcontrollers is accompanied with a previous study of the hardware design that will allow the operation of the project. It is important to conveniently choose the microcontroller model to be used, due to the wide range of models that can be adapted to specific design needs (Benchinol, 2011).

PIC16F877 microcontroller.

This microcontroller belongs to the PIC16F87X family, Microchip's new mid-range microcontroller family. It has a 40-pin DIP (Dual In-Line Package) package and its pin layout is shown in Figure 1 (Benchinol, 2011).

ISSN: 2594 - 2905

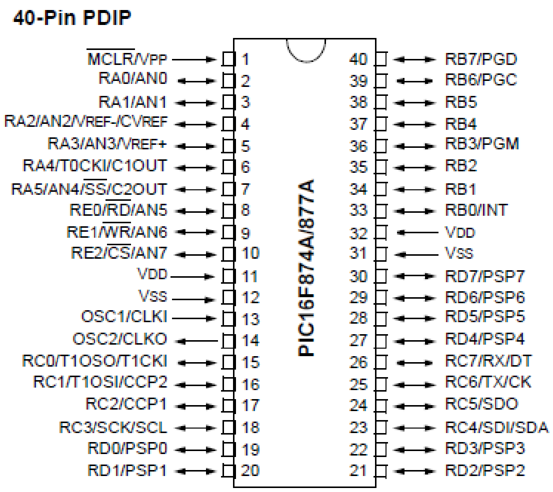


Figure 1. PIC16F877 pin layout.

Characteristics of PIC16F877.

CPU:

- 35-instruction RISC technology.
- All instructions are executed in one instruction cycle, except jump instructions which are executed in two.
- Operating frequency up to 20MHz.

Memory:

- - 8 K x 14 bits of program flash memory.
- 368 bytes of RAM data memory.
- 256 bytes of EEPROM memory for data.
- Read/write from CPU to flash memory.
- 8-level hardware stack.

Others:

- Low power consumption SLEEP mode.
- Operating voltage range from 2 to 5.5 volts.
- Temperature ranges: commercial, industrial and extended.
- 10-bit resolution A/D converter.
- 2 Timers of 8 bits and 1 of 16 bits.
- 35 digital input/output pins.
- High internal oscillator.

Power supply circuit

The PIC16F877 microcontroller is powered by 5V, which must come from a source that maintains a stable and reliable power supply.

The power supply pins for VDD are located at position 11 and 32 and for VSS pins 12 and 32.
31. It is important to place a 0.1 uF decoupling capacitor between the VDD and VSS pins to prevent transients generated by one component from entering the source, affecting other devices.

Oscillator.

The PIC16F877 allows up to 8 different oscillator modes. The user can select one of these 8 modes by modifying a special configuration register. This register is located at address 2007H in program memory and is used to configure the PIC resources.

The modes of operation for the oscillator are:

- RC: External Resistor / Capacitor.
- LP: Low frequency crystal.
- XP: Crystal for intermediate frequencies.
- HS: Glass for high frequencies.

Internal Oscillator.

The PIC16F877 has two independent internal oscillators that can be controlled by internal registers. One of the oscillators works at low frequencies and the other at high frequencies. The latter is factory calibrated at 8 MHz and its frequency can be altered by software.

External Oscillator.

It is also possible to connect a clock signal generated by an external oscillator to the OSC1 connection of the PIC. To do so, the PIC must be in one of the three modes that support crystal (LP, XT or HS).

RS232 standard.

RS232 is the name of the world's most widely used serial communication interface. The serial standard is available on virtually 99% of computers. Originally designed to connect data terminals with data communication devices, it is used to connect the communication as modems. The uses of RS232 in the home environment are many and widely known. From mouse connection, modem/fax, pocket electronic agendas, serial printers, EPROM type memory recorders, video digitizers, AM/FM radios, etc. (Guillermo herrero, 2015).

What is a circuit?

A circuit is an electrical network (interconnection of two or more components, such as resistors, inductors, capacitors, sources, switches and semiconductors) containing at least one closed path. These networks are generally nonlinear and require much more complex designs and analysis tools (Robert L,2009).

Mixed circuit.

The mixed circuit is composed of an association of resistors connected in series or in parallel, and these, in turn, are connected to other associations in series or in parallel (Robert L, 2009).

Operation.

A mixed circuit consists of elementary series and parallel circuits coupled together. None of the partial values of voltage, current and power may be greater than the corresponding total values. If the voltage at the ends of a receiver varies, the power it consumes and the current through it varies in the same proportion (Robert L, 2009).

Diode bridge rectifier.

A diode bridge rectifier is a device consisting of four diodes assembled so that an alternating current (AC) connected to two of the diodes produces a direct current (DC) output in the remaining two diodes. It is an electrical component used in many devices, for example, in cell phone chargers (Mohan, 1995).

Resistances.

A resistance is the opposition encountered by the current as it passes through a closed electrical circuit, attenuating or slowing down the free flow of electric charges or electrons. Normally the electrons try to circulate through the electric circuit in an organized way, according to the resistance they find in their path. The lower the resistance, the greater the existing order in the micro world of electrons; but when the resistance is high, they begin to collide with each other and release energy in the form of heat (Juan andrez,2006).

Voltage Divider.

It is a simple circuit that divides the voltage from a source between one or more connected impedances. With only two series resistors and an input voltage, an output voltage equivalent to a fraction of the input voltage can be obtained. Voltage dividers are one of the most fundamental circuits in at the (JuanAndrez,2006).

Optocoupler.

The optical coupler is based on the detection of emitted light. The input of the coupler is connected to a light emitter (LED) and the output is a photodetector. By encapsulating an optical emitter and detector, the optical relationship is always stable and this makes the nature of use fully electronic (JuanAndrez, 2006).

TTL TO USB

The CP2102 converter allows a microcontroller and a PC to communicate using the USB protocol in a simple way. It can also function as a "programmer" for the Arduino Mini Pro, as it includes the DTR or RESET pin needed to easily upload the sketch to the Arduino Mini Pro. Using the USB converter facilitates the integration of projects with the Arduino Mini Pro.

ISSN: 2594 - 2905

PC programs such as Matlab, Labview, Processing.

- USB 2.0 full speed 12 Mbps specification
- USB connector: USB type A
- Output pins (TTL): +3.3V, RST, TXD, RXD, GND and +5V
- Integrated USB transceiver, no external resistors
- Integrated oscillating crystal
- Internal 3.3V voltage regulator
- Reception buffer of 576 Bytes
- 640 Bytes transmission buffer
- Working temperature: -40° to 80°C (-40° to 80°C)
- Dimensions: 21 mm x 16 mm

PCB board.

A printed circuit board (PCB) is a sheet of rigid insulating material, covered by copper tracks on one or both sides, to serve as a conductor or electrical interconnection between the various components to be mounted on it.

Interface

Designed to be executed under a resolution of 800 x 600:

- User login (Figure 2).
- Main menu.

Figure 2. System Access Screen.

Main menu structure

In the monitoring screen (Figure 3) the accesses of the 11 monitored stations are linked to the complete status of the sources required for the proper functioning of the Autopilot System.

Figure 3. Main Menu screen.

Operation of monitoring equipment system.

The central monitoring stations are basically computers whose function is to monitor, consult and remotely reset the SACEM cabinets. These stations are installed in the SACEM Automatic Piloting Maintenance Stations on Line "A". There are 11 cabinets throughout the Line; represented by the station icon on the Monitoring Equipment. Monitoring is performed by entering each Station through the accesses. The interface shows the parameters of the signals obtained from the cabinets, which help the maintenance personnel to diagnose the problem with the cabinet when it is faulty.

Line A monitors 11 operating signals of the cabinet. The operation status of the signals is represented by '1's and '0's. A '1' means that the signal is active and the number '0' means that the signal is inactive.

Monitoring section structure of the SACEM automatic piloting sources.

The Voltage Sources by Station screen (Figure 4) shows the normal Operating Status of the cabinet, any change in the signal status is considered abnormal. Table 1 lists the voltage sources with their identifier.

Table 1. Voltage Sources.

SACEM autopilot voltage sources	
Sources	**Voltages**
24 Volts DC power supply	24VI
24 Volts DC VE power supply	24VE
24 Volts DC DAM power supply	24DAM
Source converter 1	CONV1
Source converter 2	CONV2
Voltage source beacons	24VBAL
Passivation signal	SPAS
MSTC signal	24MSTC
MSTD signal	24MSTD
72 Volts DC VTC power supply	72VTC
72 Volts DC S power supply	72VS
110 VAC power supply	110VAC
220 VAC power supply	220VAC

Figure 4 shows the display of the P. A. SACEM voltage sources from Table 1.

Figure 4. Voltage Source Screen by Station

Power amplifiers: 24 Volts power supply.

At this stage, different models of boards designed in Altium Designer software were built for 24V (11 sources), 72V (3), 110V (2 sources), 220V (2 sources), for the cabinet passivation system, Figure 5 shows the model for a 24V board.

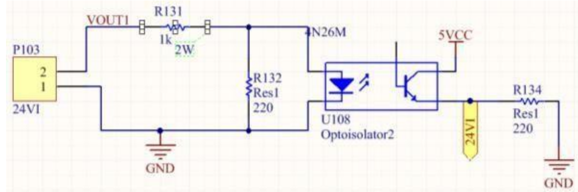


Figure 5. Power amplifier circuit 24V sources

Voltage divider calculations.

Table 2 contains the formulas applied in the mathematical calculations to determine the voltage dividers in each of the sources according to their voltage.

Formulas 24V, 72V, 110V, 220V Voltage Divider.

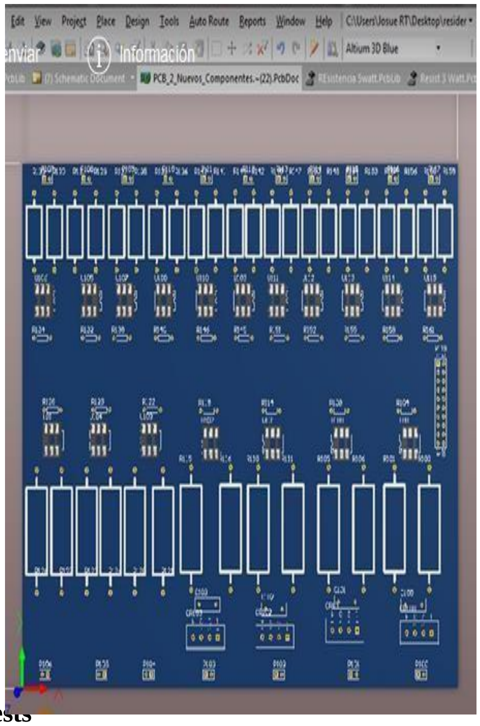
FORMULAS FOR DIVISORS	
Formula	**DESCRIPTION**
$I = V/R$	I=Intensity. V=Voltage. R=Resistance.
$P = V^{(2)}/R$	P=Power. V=Voltage. R=Resistance.
$V_x = (R_n/R_t) * VT$	Vx=Voltage divider. Rn=Resistance of Interest. Rt=Total Resistance. VT=Total Voltage.

Table 3 shows the calculations performed to obtain the voltage divider for 24 volts VDD.

Voltage divider for 24 Volts.

Voltage divider for 24 Volt VCD	
Data	**Development**
V_t= 24 V R1= 1KΩ R2= 220Ω Rt=.22KΩ	$I = \frac{24\,V}{1220\Omega} = 19.67$ mA $VR1 = (\frac{1K\Omega}{1.22K\Omega}) 24 =$ 19.67 Volts V_t - VR1= 24 - 19.67= 4.33 Volts $PR1 = \frac{24^2}{1000\Omega} = 3.86$ Watt $PR2 = \frac{4.33^2}{220\Omega} = 0.085$ Watt

Figure 6 shows the final PCB design, generated in Altium Designer, which will be used to assemble the electronic material of the project.



Tests

Figure 7 illustrates the finished product (object of this project) connected to the computer with the visual interface installed for the necessary tests.

The tests performed on the visual interface and the electronic device resulting from this research and development work were several and of different types.

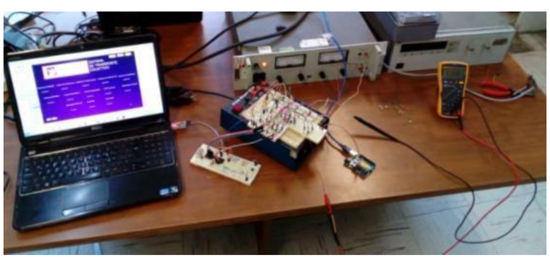


Figure 7. Connected device and visual interface.

From Access/Security to the visual interface:
A file was implemented with user names and passwords of authorized personnel to access the visual interface. Each pair of values was tested to validate user access and thereby ensure the security of the interface.

Serial port communication: Initially, to verify the serial port communication, basic test data was sent to verify that the port communication was correct by means of an on/off LED signal. Subsequently, the finished electronic device was tested by simulating the Line A stations of the interface.

Connectivity of the electronic device components:
In this testing stage, the multimeter was used as a support tool to verify the connectivity of the PCB with each component that was integrated to it. Verified the test: each component was assembled in its corresponding space with guarantee of its correct operation.

From the link of the visual interface with the electronic device:
Each of the accesses of the main menu of the visual interface was checked with its respective voltage source according to the chosen Station.
Finally, only the last stage tests were maintained periodically with the intention of making updates and performance improvements (Figure 8).

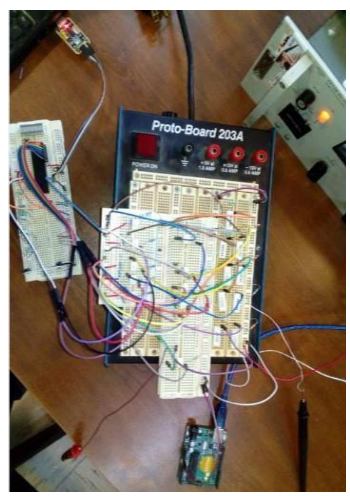


Figure 8. Connected device and visual interface.

Conclusions and Recommendations

This system has reduced intervention times when a failure or passivation occurs in the SACEM Automatic Pilot Control Cabinets, saving an average of 2 man-hours of maintenance personnel when a failure occurs, in addition to reducing the direct impact on service and ensuring the safe operation of the trains.

The implementation of this prototype is based on two important disciplines within Engineering, Electronics and Computer Science; the electronic development has allowed the implementation of a low cost data acquisition system, which allows the monitoring of the signals of the Autopilot Cabinets, while the Computer Science has allowed the design of a software tailored to the "client", making consultation of the cabinets of the entire Line A in real time, performing automatic and remote rearmings every time the Cabinet is in passive state.

The solution is integrated in the interface designed in Java of the Sistema de Transporte Colectivo allowing access to the system in real time from any point where there is a computer connected to the designed program. This development, besides being low cost, has the necessary security locks so that a cabinet cannot be rearm if it is not in passive state and if the personnel does not have the necessary credentials to carry out this procedure.

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