Figure 7. Folding the crane
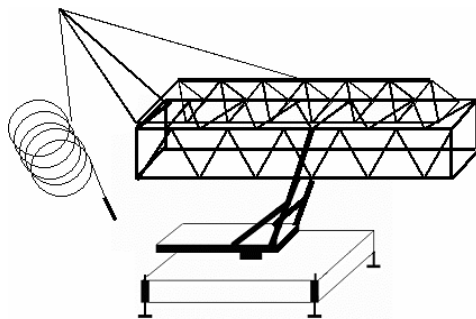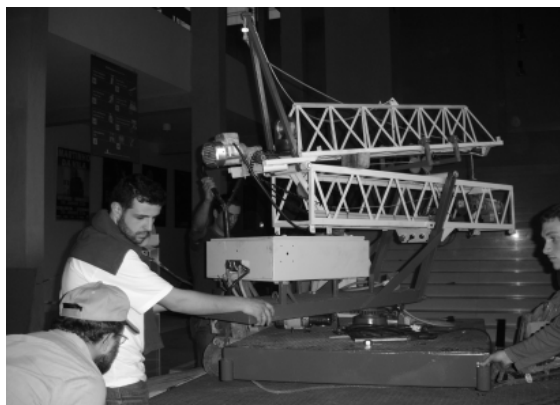

Figure 8. Folded crane

Figure 9. Folded crane being transported

3. Conclusions

A slewing crane equipped with an electromagnet has been presented. The device, built for science fair events, is capable of elevating ferromagnetic pieces of 50kg to a height of 2m from the ground.

Three three-phase induction motors produce the crane movements. An operator can make the crane slew left or right within an 180º angle. The electromagnet can be moved back, forward, up or down.

This kind of project develops the construction skills of the builders and promotes the investigation of Electromagnetism fundamentals.

4. Acknowledgements

5. References

[1] Plonus, Martin A. Applied Electromagnetics. McGraw-Hill, 1986.
[2]   Mendiratta, Sushil Kumar. Introdução ao Electromagnetismo. Fundação Calouste Gulbenkian, 1984.

Computer-Controlled Model Railroad

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Abstract. Model railroads are good test beds for several scientific experiments on Electromagnetism, Electronics, Automation, Control and Computer Science. Moreover, they are eye-catching structures very well suited for science-fair events. This paper describes a 2m x 1m model railroad layout and a user-friendly program, built with LabVIEW graphical language. The program is able to control train direction and speed, and also allows the control of thirteen switch-points, lights and a mountain funicular, all included in the layout. The interface between personal computer and railroad circuits is done with a standard multi-purpose data-acquisition board for the PCI bus.

1. Introduction

This paper describes an example of using computer control to perform an everyday task: the control of speed, direction and points of a model railroad. Such an application is a good test bed for real life systems. It is, also, a way to demonstrate how automation and computer control is present in people's daily life, although many times we do not even think about that.
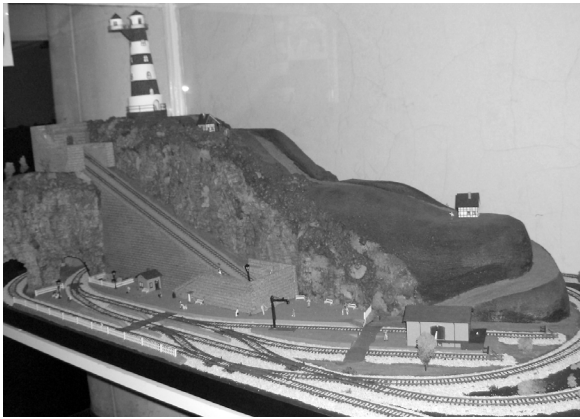
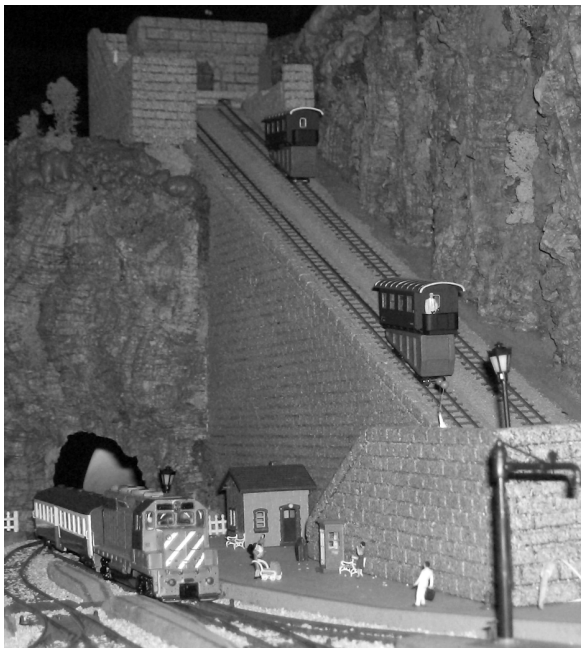## 2. Model railroad layout description

Figure 1. Model railroad

Figure 2. Model train and funicular

The model railroad (Fig. 1), with 2m x 1m, was built in HO scale (1:87). It has 13 switch-points, lights and a mountain cable funicular. The model train (Fig. 2) has a permanent magnet 12V DC motor. Train speed is controlled by the voltage applied to the tracks. Once the train starts moving, speed increases approximately linearly with the applied voltage. The lights and the points are also powered with 12V DC. A servomotor powered with 1.5V moves the funicular (Fig. 2).

The point switches have two coils over a sliding iron core (Fig. 3) and they are moved to each side by energizing the correspondent coil.
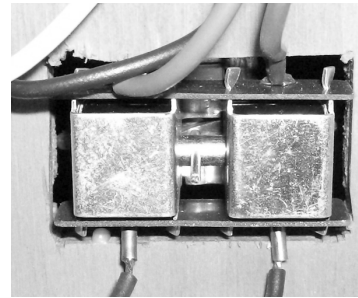

Figure 3. Point switch

3. Computer control with *LabVIEW*

The computer control of the railroad was planned in order to achieve a user-friendly interface and easy operation.

The computer control program was implemented using the graphical programming language *LabVIEW* version 6.1 [1]. The input and output of the control signals to the computer is done with a standard multifunction data acquisition board for the PCI (Peripheral Component Interconnect) bus, made by *National Instruments*, model PCI-MIO-16E-4 [2, 3, 4] (Fig. 4). This board has 16 analog inputs, 2 analog outputs, 8 digital inputs/outputs and timers.

Figure 4. Computer, data acquisition board and railroad layout

The control program user interface is based in the actual model railroad layout. The virtual control devices (switches) were placed in correspondent positions of the model railroad switch-points.

The software development was initiated having in mind the particular needs of the application and a number of practical limitations of the data acquisition board. The 13 switch-points of the railroad model are actuated by 13

virtual switches. Since each switch-point has two coils (one for each direction), 26 digital output signals are needed. Also, the lights have to be switched on or off, as well as the funicular, and the train direction of movement must be controlled. So, 29 digital output signals are needed. But the board only has 8 digital outputs. The solution was to implement signal multiplexing: a control bit is periodically outputted to each device to be controlled, using 1 digital output. Whenever a control bit is outputted, a 5-bit code is also outputted (using 5 digital outputs), identifying the device to be controlled (a 5-bit code allows using up to 32 devices). One disadvantage of multiplexing is a short delay between user command and actuator output.

Train speed was controlled using an analog output. The selected speed in the program user interface is converted in a voltage value outputted by the data acquisition board.

From the remaining 2 digital outputs, one was used to command the layout power switch.

The built *LabVIEW* application is shown in Fig. 5 and Fig. 6.

The data acquisition board does not provide enough power or number of signals to allow it to be directly connected to the model railroad. Several interface circuits are then required:

- One circuit is the speed regulator: since the correspondent board analog output does not supply enough voltage and current, it must be connected to a power amplifier, namely a power transistor.
- Another circuit is the direction of movement controller: this is also implemented with four power transistors, which act as a voltage inverter.
- The switch-point actuators must also have a drive circuit, which may be a power transistor for each one of the two coils.
- Finally, another very important circuit is the demultiplexing unit. It is responsible for decoding the 5-bit code that represents a determinate action to be performed. This unit is implemented with four 3 to 8 demultiplexers plus two 2 to 4 demultiplexers.
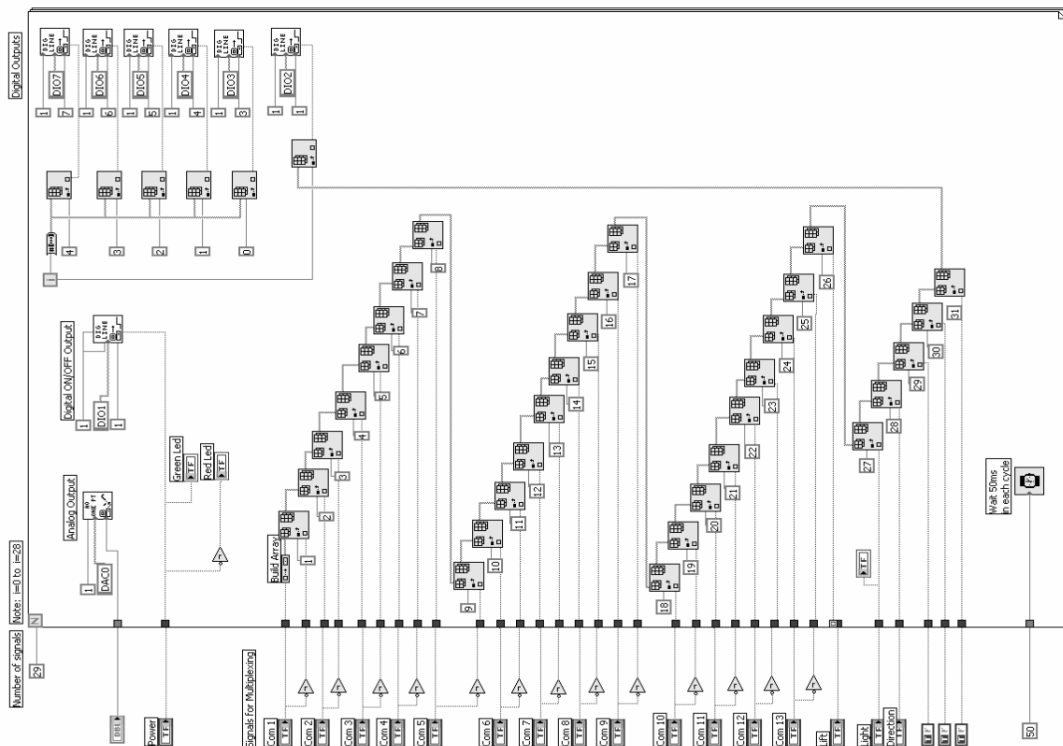
4. Interface circuits

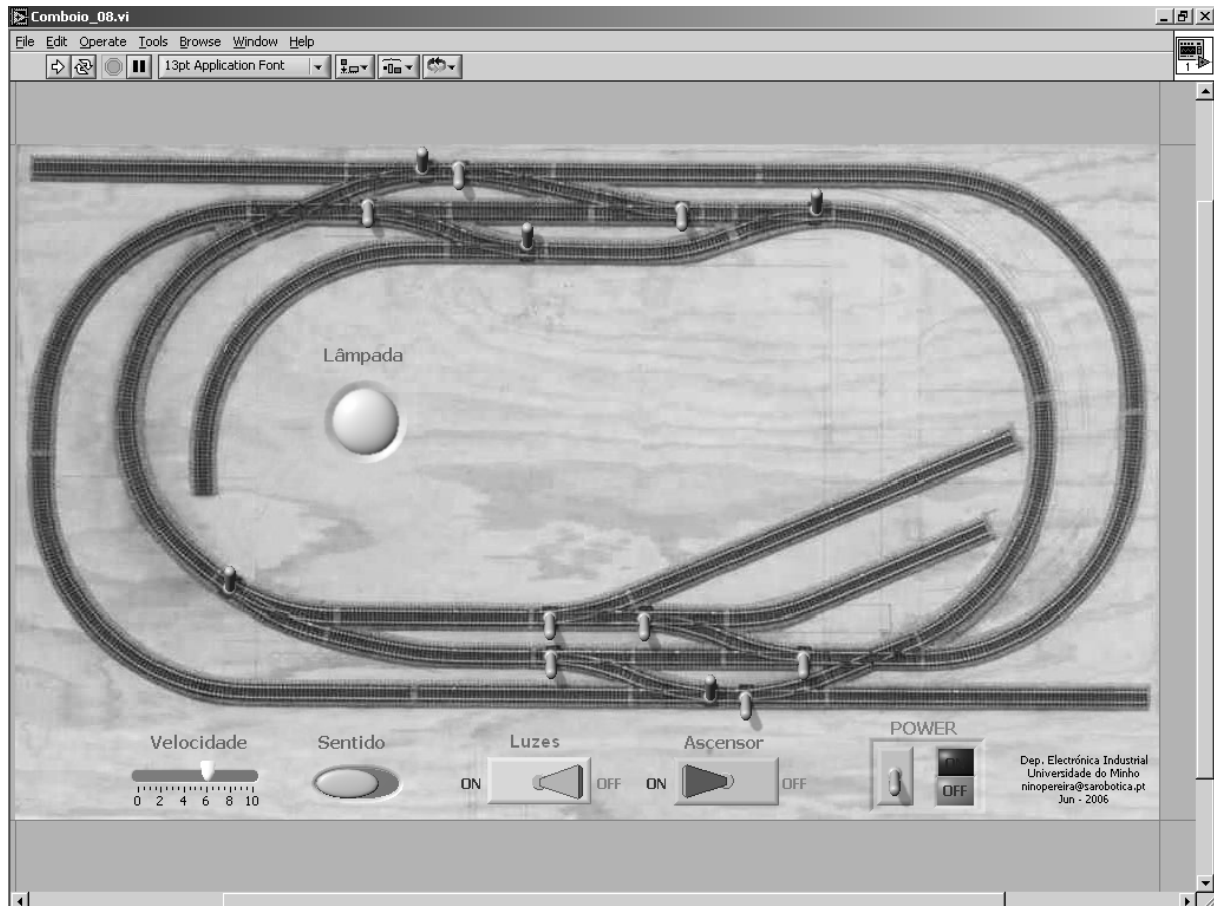**Figure 5. *LabVIEW* Program block diagram**

Figure 6. *LabVIEW* Program front panel

5. Conclusions

A user-friendly program, built with *LabVIEW* graphical language, has been developed to control a 2m x 1m model railroad layout. The program is able to control train direction and speed, and also allows the control of thirteen switch-points, lights and a mountain funicular.

This work demonstrated that automation and computer control may be used in daily applications. However, interface circuits between computer and actuators are almost always required, as well as standard data acquisition boards, because a personal computer was not originally designed to perform these kinds of tasks.

The *LabVIEW* graphical programming language provides a very user friendly and easy to use interface.

This system proved to be very flexible, easily allowing other kinds of tasks – which were not implemented – such as sensor reading, system monitoring and data logging.

6. References

[1] *LabVIEW^{TM}* User Manual, Part Number 322661A 01 - National Instruments Corp, July 2000 Edition.
[2] DAQ Getting Started Guide, document nº 373235H - National Instruments Corp. September 2005.
[3] INSTALLATION GUIDE Traditional NI-DAQ (Legacy), document nº 374279A-01 - National Instruments Corp. October 2005.
[4] Full-Featured E Series Multifunction DAQ 12 or 16-Bit, up to 1.25 MS/s, up to 64 Analog Inputs - National Instruments.