Using CompactRIO to Characterize the Energy Performance and Hydrothermal Behavior of Various Wooden Building Systems

Installation of Sensors on Various Wall Types

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The Challenge:

Developing an autonomous communication system for humidity and thermal data acquisition and energy metering in buildings to determine a mathematical model for heat and humidity exchange in different wooden buildings.

The Solution:

Using the NI CompactRIO platform and the integrated power of field-programmable gate arrays (FPGAs) to interface easily with specific components and to personalize a multichannel data acquisition and communication system.

Author(s):
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The TRANSBATIBOIS project, started in eastern France, brings together scientists; wood material, energy transfer, and building physics specialists; and companies representing different wood construction systems to study the transfer of heat and humidity in wooden buildings.

Owner of a 7500 m^2 specialized laboratory, CRITT BOIS (Regional Center for Innovation and Technology Transfer) offers resources to help companies in the wood industry conduct research. We coordinated this project and set a goal to develop an autonomous measurement system that can communicate data. The system would be replicated on several sites.

Communicating With More Than 500 Sensors Using the I^2C Protocol

We needed to acquire different temperature, humidity, and gas measurements with sufficient accuracy and speed. However, we also needed to control cost, so the project team selected an inexpensive digital sensor for temperature and humidity (about 15 € per sensor). These sensors can measure the temperature to the nearest tenth of a degree Celsius and relative humidity to the nearest tenth of a percent. The project currently has more than 500 sensors installed, so choosing an inexpensive sensor helped to significantly reduce cost.

One reason we chose a CompactRIO system was because we could customize it using FPGAs. The FPGA is integrated into the CompactRIO chassis and we can program it to implement any type of communication protocol with a digital I/O module. This helped us meet the difficult challenge of communicating with the inter-integrated circuit (I^2C) protocol, which was required by the sensor manufacturer.

The I^2C protocol uses a DATA channel for bidirectional communication and a CLK channel to synchronize the communication. We implemented the I^2C protocol using the FPGA in an NI 9403 C Series Digital I/O module. With an NI 9403, we can communicate simultaneously with 31 sensors, or 248 sensors using a CompactRIO chassis housing eight NI 9403 modules. Therefore, we can take 248 temperature and 248 relative humidity measurements simultaneously.

We developed the LabVIEW FPGA program and then optimized it to make sure it can execute in the 2M Gate FPGA circuit in the NI cRIO-9074 chassis. We used parallel programming for each data acquisition module to rapidly acquire data.

Using Modular Programming to Promote Maintenance

To obtain usable results, we needed to acquire data at different sites with different sensor implantation typologies. In the interest of maintaining the software, we developed a program using the LabVIEW Real-Time Module that any LabVIEW FPGA program installed on the C Series modules to perform signal acquisition. In short, each FPGA program is different depending on the type of data acquisition module being used, but the LabVIEW Real-Time program remains the same regardless of the modules inserted in the CompactRIO chassis. We used a variety of modules including the NI 9403, NI 9213, NI 9411, NI 9205, and the NI 9472.

We conducted proportional-integral derivative (PID) control using an NI 9472 to regulate the environmental chambers for specific tests in the laboratory regarding thermal and humidity exchanges in wood wall frame models.

Developing a Remote Communication System

We installed 14 CompactRIO chassis at seven sites across eastern France and they all communicate with a data server. Using this configuration, we can quickly analyze and effectively exchange information.

The climatic conditions of each site, such as the temperature, wind speed, precipitation levels, and barometric pressure, are also sent to the data server to better understand the physical values received.

Developing a System That Easily Adapts to Other Applications

This modular data acquisition system can acquire any type of signal emitted by the C Series modules. The architecture of the program remains unchanged regardless of the hardware configuration, which means that it is quite easy to implement it on any industrial application. In addition to unique hardware modularity, this system provides important financial benefits over other solutions currently on the market. This hardware configuration is now given by CRITT BOIS for energy management and building applications.

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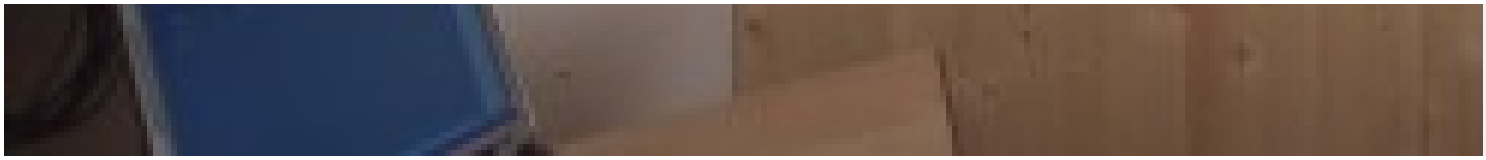

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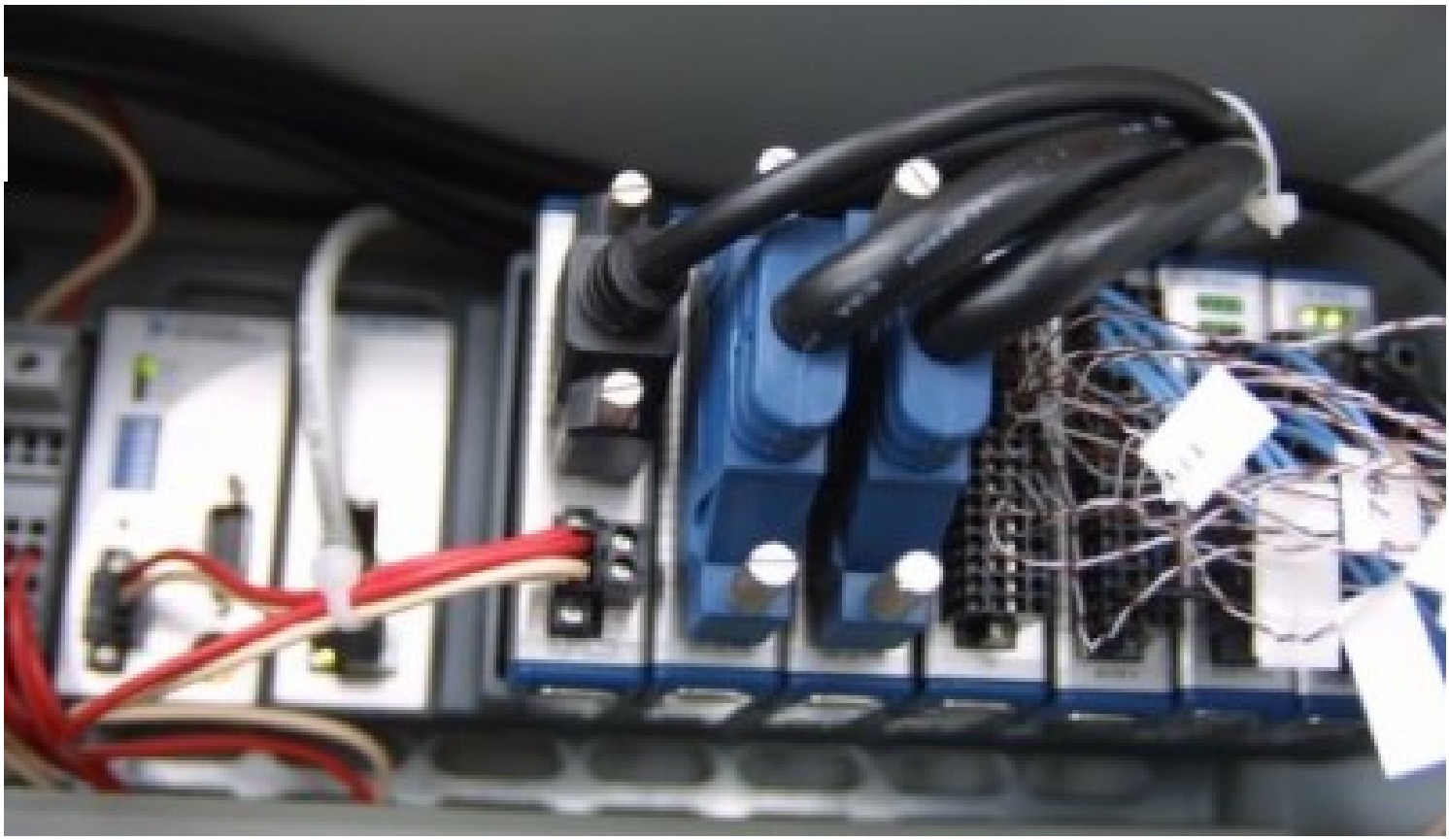
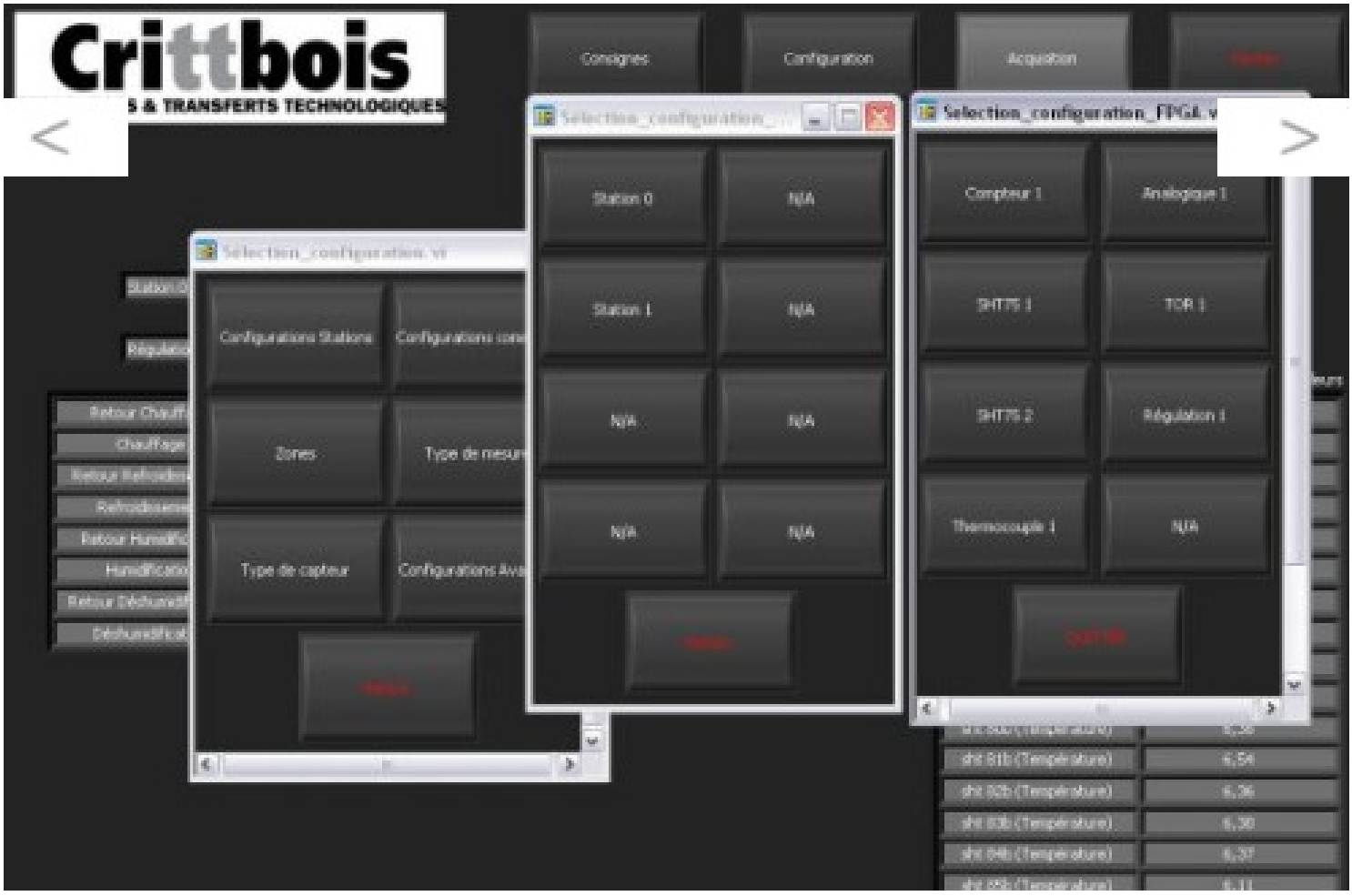


CompactRIO System Installed in a Control Cabinet



Setup and Configuration of a CompactRIO Chassis and C Series Modules

Digital Temperature and Relative Humidity Sensors on Wooden Walls

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