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EXPERIMENTAL ELECTRONIC INSTRUMENT FOR A HYDRAULIC TOWING WINCH

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The objective of this work is the design and implementation of an experimental electronic instrument that will be used for the automation control of an hydraulic towing winch. This electronic instrumentation system integrates the controller and the human machine interface (HMI). For this reason, an experimental programmable automation controller has been developed.

The heart of most machine control applications is an electronic controller such as a programmable automation controller (PAC) or programmable logic controller (PLC) [1]. The controller is used to receive sensor data and to control the machine using analog and digital I/O signals, and mathematical algorithms like PIDs [2]. Traditionally PLCs have been used in machine control and they are programmed using tools such as ladder diagrams or sequential function charts. One of the biggest benefits of using a PAC is the ability to add other tasks to the control application, which could not be handled by a traditional PLC [3]. For this reason, increasingly machine control is moving to PACs because they offer higher performance and more functionality, allowing operations such as high-speed data acquisition and processing, as well as motion control and vision which are not supported in traditional PLCs [1, 4, 5].

The designed electronic instrument must accomplish the control requirements for a naval deck machinery, composed by a tug winch with an hydraulic pump feeding four hydraulic motors, linked together to a towing drum [6]. The electronic instrument architecture, including the machine controller hardware and software, has been defined considering the following characteristics: (i) combination of HMI and real-time control in the machine control system; (ii) ruggedness, flexibility and modularity; and (iii) the availability of common intuitive development software for programming all the elements of the system [4, 7].

From the previous considerations, the adopted solution was based on a National Instruments (NI) CompactRIO PAC, a modular low-cost reconfigurable control and acquisition system designed for applications that require high performance and reliability. The system combines an open embedded architecture with small size, extreme ruggedness, and hot-swappable industrial I/O modules. NI CompactRIO is powered by reconfigurable I/O (RIO) field-programmable gate array (FPGA) technology. This solution comprises a CompactRIO chassis and real-time embedded controller (NI cRIO-9014) and several I/O modules (NI 9205, NI 9203, NI 9265, NI 9425, NI 9477). Figure 1 illustrates the architecture of the electronic instrument and software tasks running in HMI and Real-time Controller.

To take advantage of all the features and capabilities of a PAC, it is fundamental that the application code was well designed, coordinating various controller processes such as I/O, process control logic, communication to a HMI and other tasks [1, 5]. The LabVIEW Real-Time Module 8.6 introduced powerful new features for programming CompactRIO hardware that reduce development time and complexity as well as provide tools for monitoring and maintaining CompactRIO applications [8]. The basis of the CompactRIO PAC is the FPGA which performs the interconnection of the I/O modules and offers performance maintaining the flexibility. CompactRIO is entirely programmable with LabVIEW, including the FPGA, real-time processor, and human machine interface. The system was divided in several independent basic functional blocks or mod-

ules. These functional blocks improved the modularity and the flexibility of the system. This structure facilitates the addition of new elements to the system or the design of whole new system, simply by the design and addition of new software modules, or by the reuse of the existing ones.

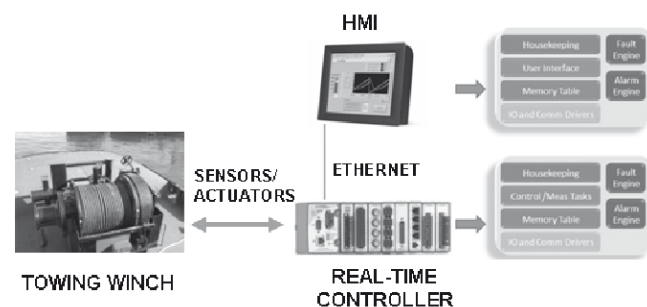


Figure 1: Architecture of the electronic instrument and running tasks.

Since the state diagram considers each possible state of the system, the use of LabVIEW Statecharts provides a system-level view that describes the complete function of a module, a system or an application [9]. Therefore, the use of Statecharts reduces the possibility of unexpected behaviour, because the state chart definition of a module forces to take into account the possible scenarios to which the software needs to respond.

The LabVIEW development tool also provides a powerful debugging and testing platform, so each module was previously verified and simulated using virtual panels and virtual machines (inputs/outputs). This virtual panels and machines allowed the functional verification of each module and the whole system.

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