ASEE-ETD Mini-Grant Project Final Report

Project
Cost-Effective Upgrade to Instrumentation and Controls Laboratory

Project Director
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Description
This project explored the design, fabrication, and integration of relatively low-cost PLC-based laboratory equipment for the automation and control courses offered by LeTourneau University’s Engineering Technology Department.

Accomplishments
The following project milestones were completed:

- Six free-standing PLC training units were designed and fabricated by the Project Director, students in class, and paid student workers. Each unit contains a Siemens S7-1215C PLC, power supply, and various indicators and controls of the type used in industry. Also included are provisions for system expansion through cable connections to other hardware assemblies.
- Six relay logic board assemblies were designed and built using DIN rail-mounted relays interconnected to form simple, hardwired combinational logic circuits. The relay boards were cable-connected to the indicators and controls on the PLC training unit (with PLC disconnected) and provided students with foundational knowledge of pre-PLC relay ladder logic.
- Siemens TIA Portal STEP 7 PLC programming software was installed on each lab PC and the license keys were installed on the campus LAN license server.
- Ethernet jacks were activated in the PLC lab to provide connection points for each PLC.
- Six scale model conveyor belt assemblies were designed and fabricated. Each contains a belt drive motor, a reject arm motor, several proximity sensors, operator pushbuttons, and indicator LEDs. Provisions were included for cable-connection to each PLC training unit for PLC control.
- Development was begun on a prototype floating-ball-in-tube assembly with three-phase blower, VFD, and ultrasonic ball height sensor. A distance sensor was configured to
detect height of ball in clear, vertical tube as input to PID loop for controlling motor speed.

Outcomes Realized
- At the end of this project, six complete RLL racks, six PLC training units, and six conveyor belt assemblies were designed and built to support a variety of PLC experiments.
- Students found the fabrication and experimentation with the new laboratory hardware to be a positive experience.
- Students successfully learned PLC programming through the use of this new hardware.
- Various project-related photographs and video recordings are available at https://tinyurl.com/PLC-Photos.
- Design files and laboratory experiment examples are available upon request.
- Overall, this project was a success due to the support of ASEE-ETD and other sponsors.

Project Budget
Details of the project expenses and funding are shown in Table 1 and Table 2, respectively.
Table 1: Project Expenses

<table>
<thead>
<tr>
<th>Unit</th>
<th>Item</th>
<th>Unit Cost</th>
<th>Extended Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main PLC Rack (qty 6)</td>
<td>Siemens 1215C PLC, KTP700 HMI, and S7-TIA software license</td>
<td>$0*</td>
<td>$0*</td>
</tr>
<tr>
<td>Controls and indicators for PLC rack</td>
<td></td>
<td>$0*</td>
<td>$0*</td>
</tr>
<tr>
<td>Aluminum extrusions, power supply, fasteners, wiring, and other electrical/electronic items</td>
<td>$1,077</td>
<td>$6,462</td>
<td></td>
</tr>
<tr>
<td>Lab network jack installation and activation</td>
<td></td>
<td>$150</td>
<td>$900</td>
</tr>
<tr>
<td>Relay Logic Rack (6)</td>
<td>Relays, DIN rail, connector, cable, and miscellaneous hardware</td>
<td>$65</td>
<td>$390</td>
</tr>
<tr>
<td>Conveyor Belt (6)</td>
<td>Pulleys, motors, aluminum enclosure, fasteners, sensors, wiring, and other electrical/electronic items</td>
<td>$356</td>
<td>$2,136</td>
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<tr>
<td>PID Floating Ball-in-tube (1)</td>
<td>Three-phase blower, VFD, enclosure, miscellaneous hardware, fasteners, sensor, and wiring</td>
<td>$455</td>
<td>$455</td>
</tr>
</tbody>
</table>

* - $0 means item was donated

Total: $10,343

Table 2: Project Funding

<table>
<thead>
<tr>
<th>Fund Source</th>
<th>Amount</th>
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<tr>
<td>ASEE Mini-Grant</td>
<td>$1,300</td>
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<tr>
<td>Donor</td>
<td>$5,000</td>
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<td>LeTourneau University</td>
<td>$4,043</td>
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</tbody>
</table>

Total: $10,343