

"Frac" Pump Controller

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NI Product(s) Used:

LabVIEW 2011
NI cFP-2120
NI cFP-AI-111
NI cFP-AO-210
NI cFP-CB-1
NI cFP-RLY-425
NI cFP-BP-4
NI cRIO-9025
NI 9208
NI 9264
NI 9481
NI cRIO-9112

Categories:

Advanced Control Systems
Automated Test
Energy

The Challenge

The client needed a Real-Time system capable of monitoring and controlling a well site fracturing (Frac) pump truck. The application need to include the ability to adapt to an ever changing environment to offer reliable well fracturing control along with supreme safety.

The Solution

Using multiplatform LabVIEW along with FPGA executing on a cRIO chassis and c-Series modules, Data Science Automation was able to create a Real-Time application with built in safety procedures that would communicate to a Windows based LabVIEW application for operator specific control.

Introduction

Data Science Automation (DSA) is the premier National Instruments Alliance Partner. DSA integrates commercial off-the-shelf (COTS) components from automation technology vendors to create custom, adaptive automation solutions for a diversity of research, manufacturing, government and business operations to:

- acquire, analyze, present and manage data
- design, simulate, test and validate products
- monitor, predict, control and optimize processes
- invent, draft, prototype and build machines

for maximum productivity, quality, profit and understanding.

DSA is a certified member of the Control Systems Integrators Association (CSIA) and staffs multiple National Instruments Certified Training Centers with more certified LabVIEW Architects than other integrators.

DSA was selected by the client because of our depth of experience in the development of oil and gas industry field applications that required following a disciplined software engineering approach that would ensure robust performance when deployed. DSA's extensive number of Certified LabVIEW Architects with extensive industrial experience also provided the client a level of confidence that his investment would be compounded.

Approach

The Well Fracturing Pump Control (FPC) system was created due to DSA's client's needs for a robust, reliable and affordable hardware and software solution for controlling the safety and costs of a well fracturing ("frac") pump. There are multiple operational hazards to both the environment and personnel along with high liability costs if an operational failure occurs on a well fracturing site. The client wanted a software and hardware application that would not only be cost-effective to develop but also compound their investment many times over.

On a well fracturing job site there are many different hazards that an operator has to monitor while maintaining the correct volume and pressure to ensure proper fracturing of the reservoir. For a reservoir to become fractured and start producing material profitably, the well fracturing crew must inject into the well a specific amount of material at a specific pressure. The pressures can exceed 15,000 Pounds per Square inch at an injection rate of over 10 barrels per minute. At these high pressures and flow rates having an operator close to the pumps can be dangerous. To minimize the chance of injury, the FPC allows the human operator the ability to be located safely away from any immediate danger. Also the FPC monitors not just pressure but also pump efficiency, engine, transmission and a variety of other inputs to ensure pump failures will not endanger personnel or equipment.

Legacy Control System

Prior to the FPC application, for a well fracturing operator to operate a pump, the operator would either have to be physically stands next to the pumping equipment changing physical dials such as throttle and gear or be tethered to a control box that may only be a few feet away for the pumping equipment.

The legacy control systems, though they did have built in safety setting, had multiple turn dials and digital set point controls. The multiple locations of set points and controls could be separated over a large enough area, forcing the operator to move from one are or another. This motion could become tiresome or dangerous. Also the previous control system simply had a combination of multiple subsystems to control the pump. The subsystems worked together but were disjointed in operational features. The FPC control integrates all legacy system functionality into a single control module with a common interface. Also the legacy control system did not incorporate a proportional-integral-derivative (PID) controller, which meant the operator would continuously monitor the pump flow and gradually adjust the pump throttle position or gear to ensure the correct volume was being supplied to the well. This could entail continuously changing gear and throttle manually and was inaccurate.

FPC Conception

The FPC system was created not only to significantly increase the safety and productivity of a well fracturing job site but also to be cost effective and user friendly. To maximize the cost effectiveness, DSA chose to incorporate the cRIO FPGA control system with C-Series module integration. By selecting the cRIO hardware architecture, DSA was able to incorporate high speed and high channel density hardware into a compact footprint while not sacrificing computational speed or accuracy.

The fundamental process driving the FPC application was the ability to have a single touch panel computer running Windows 7 capable of communicating with any well fracturing pump located on-site (Figure 1). This meant that DSA had to incorporate the ability to automatically detect when pumps were available and what capabilities were of each pump. Capabilities would include but not be limited to maximum continuous pressure, maximum flow rate, available hydraulic horse power, etc. Once a communication connection was established, the pump operator had the ability to select from multiple possible operating modes, each mode having a different function related to the frac job (Figure 2).

PID verses Manual control

Prior to the FPC system, an operator would have to monitor a sensor, such as a magnetic flow meter or densometer, which had inaccuracies and long settling times. Based on the sensor reading and the desired flow rate, an operator would have to manually decide what gear and throttle position was needed to accomplish the task. During the settling period the operator would have to monitor things like gear slippage and transmission temperatures. They would even have to try and predict if the

requested rate was available based on the well head pressure since as the pressure increases on the pump the available rate decreases due to losses in hydraulic horsepower. DSA was able to provide this legacy manual operation mode in a concise touch panel interface (Figure 3) but also expand the system to provide automated PID control.

Previously, all of this information had to be processed continuously by the operator to ensure maximum efficiency of the pump. With the creation of the FPC system, the operator could simply request a volume (Figure 4). Once the volume was accepted the FPC would determine the best course of action to ensure maximum efficiency of the pump system. Also the FPC system had direct access to the pump rotation sensor so calculations based on shaft rotation could be quickly converted to volume. Thus the settling times need for the other sensors was removed. Once the setpoint had been entered, the operator could then direct his or her attention elsewhere resulting in more productive utilization of the site personnel.

Benefits of Partnership

The Alliance partnership between Data Science Automation and National Instruments has allowed DSA to tackle many extremely complex engineering challenges while maximizing our client's return on their investment. The FPC project was no exception, by selecting LabVIEW Real-Time Data Science Automation was able to create a software package that not only reduced the overhead costs but also greatly reduced the client's productivity losses by eliminating operational mistakes. Also by using National Instruments hardware and software, the FPC application was able to allow the client to reuse existing equipment investments, specifically in the area of cRIO hardware. These savings allowed additional investment in the development of additional applications.

Conclusion

Overall the FPC application was able to reduce the client's overall costs by reducing the operational material lost and reducing operational errors created by operator interactions with complex equipment. By incorporating Certified LabVIEW Architects with National Instruments hardware and LabVIEW software Data Science Automation was able to create the FPC application which reduced the overall project risk and total cost of ownership for the client. With the ability to apply innovative approaches using National Instruments products Data Science Automation was able to methodically apply adaptive automation technologies to reduce risks and costs to the client.

Contact Information

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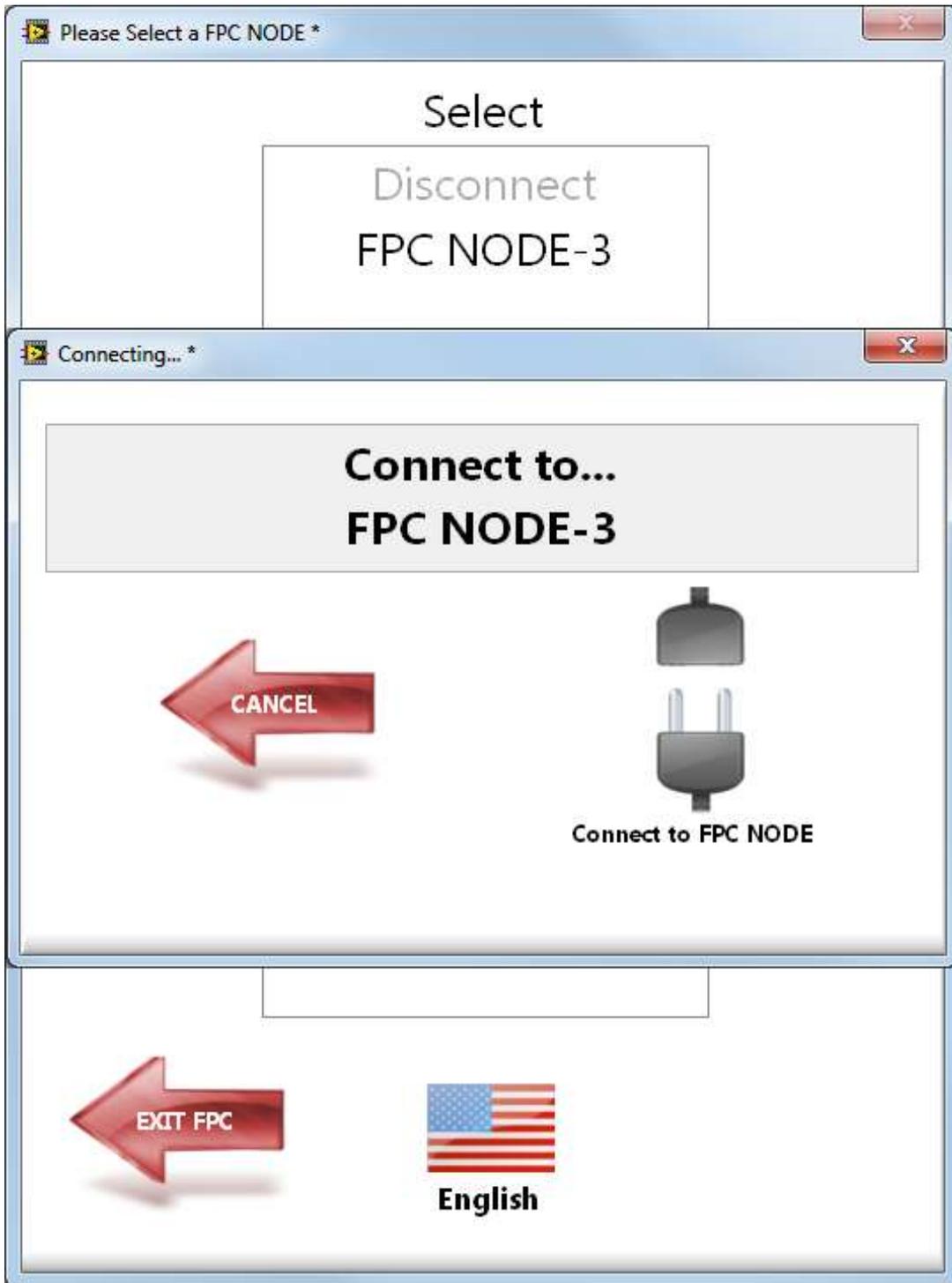


Figure 1. Validating FPC NODE Connection

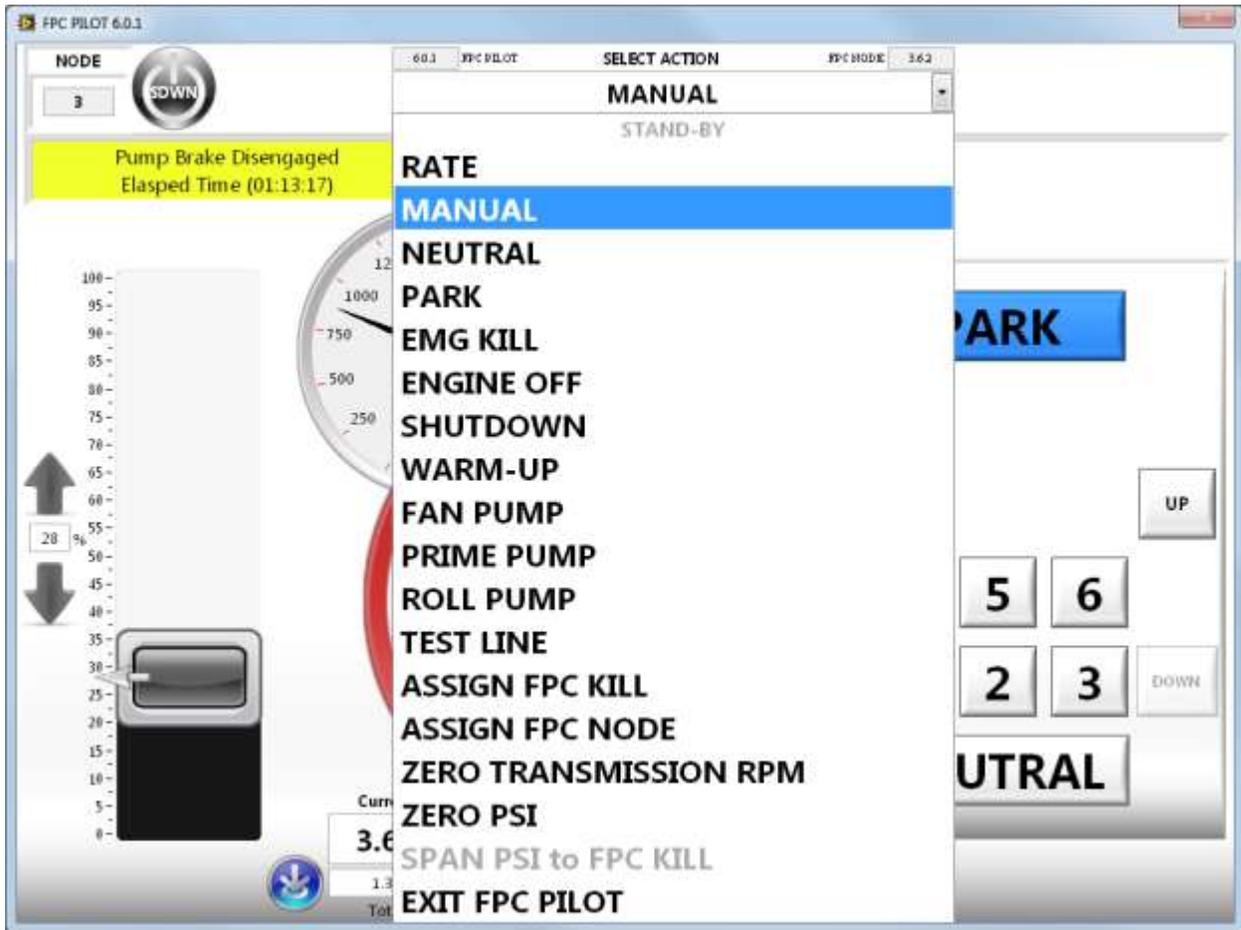


Figure 2. FPC NODE Mode Selection

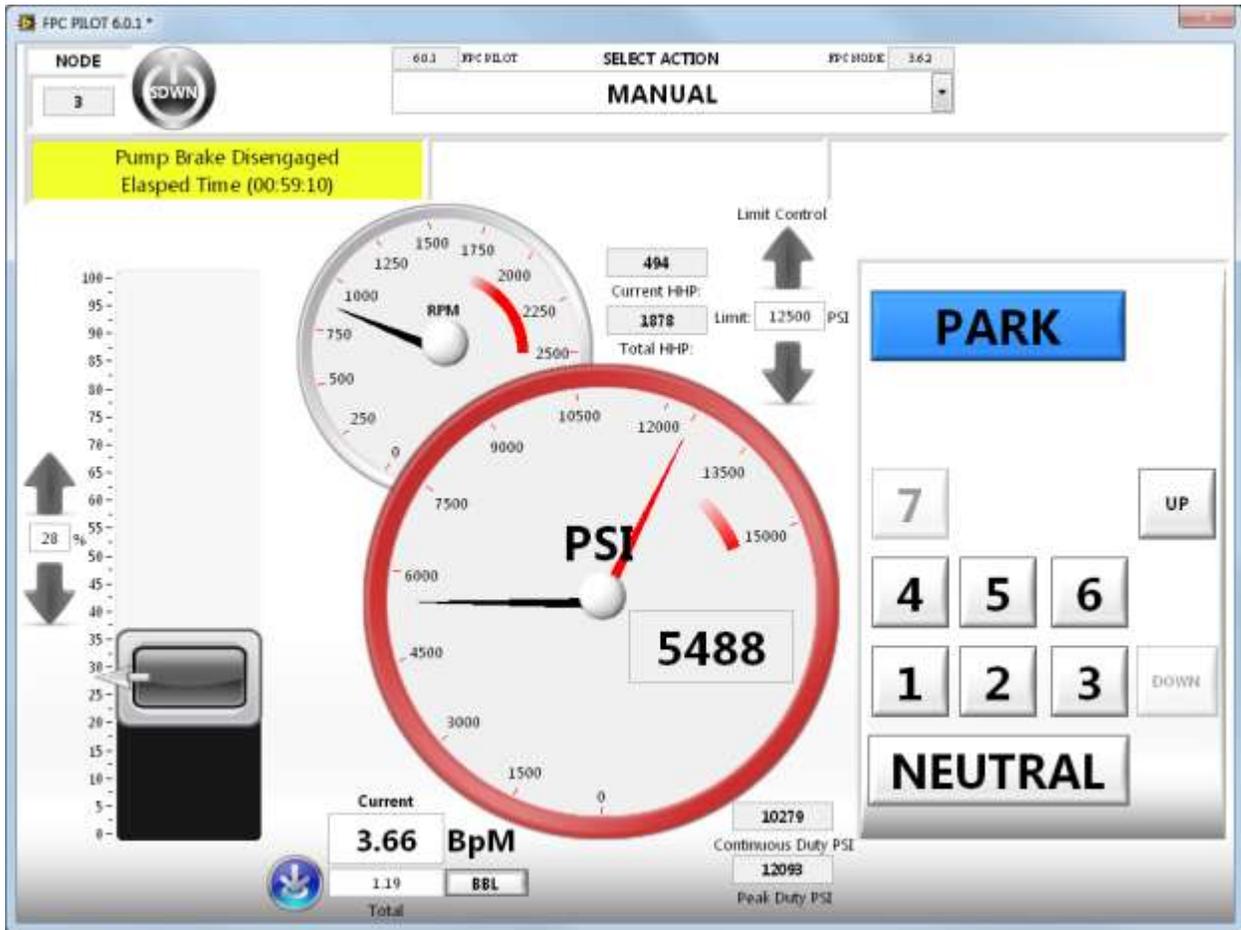


Figure 3. FPC Manual Mode Screen (with Pump Warning Text)

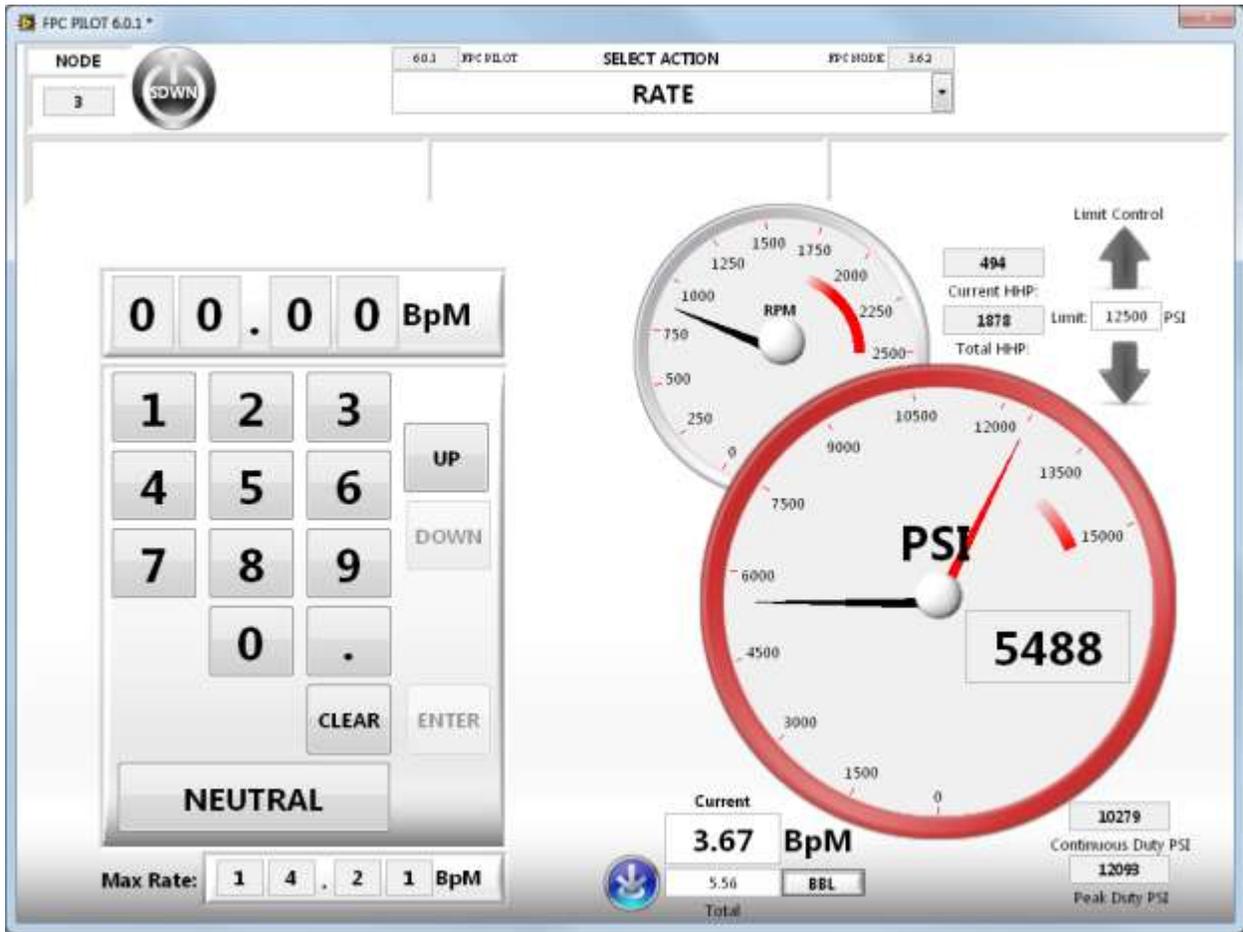


Figure 4: FPC Rate Mode Screen