Multiple Fracturing Pump Control System

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NI Products Used:
LabVIEW 2011
cFP 2120
cFP AI 111
cFP AO 210
cFP CB-1
cFP-RLY_425
cFP four slot back plane
cRIO-9025
NI 9208
NI 9264
NI 9481
cRIO-9112

Category:
Advanced Control Systems
Energy

The Challenge
The client needed to have a system to control multiple well fracturing pumps from one computer using previously designed LabVIEW code made to control one pump at a time. The application needed to be able to launch multiple executables of the other application and monitor and control the system.

The Solution
Using LabVIEW, Data Science Automation was able to create an application that launched the other application and tied into the data and controls to monitor and control the Real-Time (RT) targets. This allowed the customer to control up to sixteen well fracturing pumps on a single computer.

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

This process was needed when the equipment of a leading well fracturing company wanted to have their equipment automated. The operators of the equipment needed a way to have one operator control the group of pumps from a single location and have the ability to set a flow rate and maximum pressure and have the equipment determine the best solution to get the job done.

The multiple fracturing pump control (MFPC) application that was created would allow for more than one controller to be online at a time. Each pump control application would have the operator select a color for the group of pumps under their control. Once the operator had selected the pumps that they wanted to control, the pumps would be locked out and other MFPC operators would not be allowed to connect to those pumps until the operator released control by programmatically disconnecting from it. Each pump would have a Compact Field Point (cFP) or a Compact RIO (cRIO) on it that had been previously configured with the correct parameters for the operation of the pump and the feedback needed to monitor the control. A single pump control application was also created in LabVIEW before the MFPC was designed. The single pump control code only need slight modifications to enable the new MFPC application to take advantage of that already functionality due to the adaptive design techniques that were used.

The operator would use a well setup screen, shown in Figure 1, to customize the well layout. This included the direction of the well head and the pumps they would be controlling on the "missile" (pump manifold). The missile is the main piping that was connected to all the pumps and the well head. The operator would also need to set the maximum pressure allowed to prevent a blow out as a safety measure. The operator can adjust the maximum acceptable pressure by use of the pressure setup screen as shown in Figure 2. This setting will be used on all pumps controlled by the pump control application and could be upwards of 10,000 PSI. The algorithm on the real-time controllers will look at the input pressure and predict the next set of pressure readings to determine if the pressure might exceed the set limit. This important feature will help the crew avoid bursting the pipes and avoid injury.

Once the pumps were selected and the pressure limit set, the MFPC application would allow the operator to select a rate at which they would like to operate. The application would create a solution to operate the pumps that would check for harmonics based on the types of pumps being used and their operating settings. The operator could also select an individual pump and remove it from the solution if the pump was not running at acceptable performance. The operator could also lock an individual pump into a gear and throttle level if desired. Once the application was started the operator could select the rate screen, shown in Figure 3, and modify the rate to a new rate. The rate would only take affect after the operator clicked on the commit button.

Each group of pumps is assigned a color and the operators of the individual applications will select a color from the color selection screen. Once a color is selected by the operator that color will appear disabled and grayed-out to all of the other MFPC operator's on their selection screen to avoid pumps being ganged to the wrong MFPC application.

The main screen shown in Figure 4 will show the connected pumps and display the values for each pump as well as if it is locked out or not and the connection status. The controls can be clicked on to bring up the desired controls. The HHP and RATE controls at the top can be clicked on to bring up the scoreboard that provides the totals of all the pumps on the network and the pumps under the MFPC's control. This allows the operators to manage their work load with the other operators. By clicking on the warning light an error and warning panel will be displayed to provide a description of the warning and the pump number it is associated it. Clicking on the pressure will bring up the pressure setup screen and clicking on the rate indicator will bring up the rate selection screen. The drop down menu in the center of the upper main screen will allow the user to select any of the main functions as well as neutral and shutdown functions. The warning and scoreboard screens are shown in Figure 5.

Being a LabVIEW Certified Developer (CLD) and working with other CLDs and LabVIEW Certified Architects (CLA) on a daily bases made creating this application a joy to work on. The availability of having the other code for controlling the single pump made it easy to tie in the new multiple MFPC application. Using some of the standard LabVIEW architecting only slight modification to the existing code were needed to the existing single pump control code.

This MFPC application makes it easier for the operator to control multiple pumps from a single location that can be a safe distance from the high pressure piping. The previous method for controlling these pumps was for the operator to stand next to the pump and use levers and controls to adjust the pump output. The pumps were outfitted with a cFP or a cRIO and a different application also created in LabVIEW was used to apply the correct image and parameters to the National Instruments (NI) hardware. A variety of analog inputs and outputs were used with relay cards to control the pumps remotely.

Overall, the application designed by DSA using LabVIEW was able to fill the customers need and provide them with the ability to reduce the number of operators and place the operator a safe distance from the more dangerous area of the wellsite. It also allowed for better control of the process and with the additional system components make the entire process much safer.

Contact Information
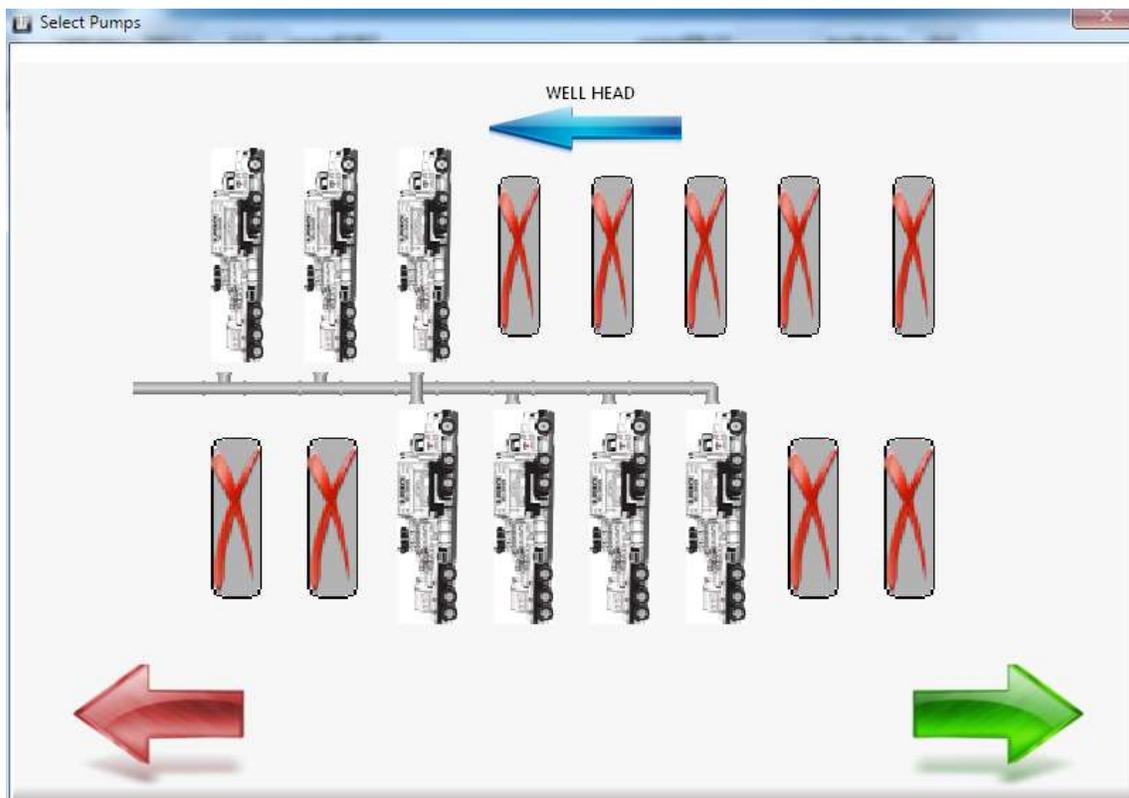Ronald J. Cochran, 724-942-6330, www.DSAutomation.com

Figure 1. This is the well setup screen that allows the operator to select the position of the pumps that their MFPC will control.
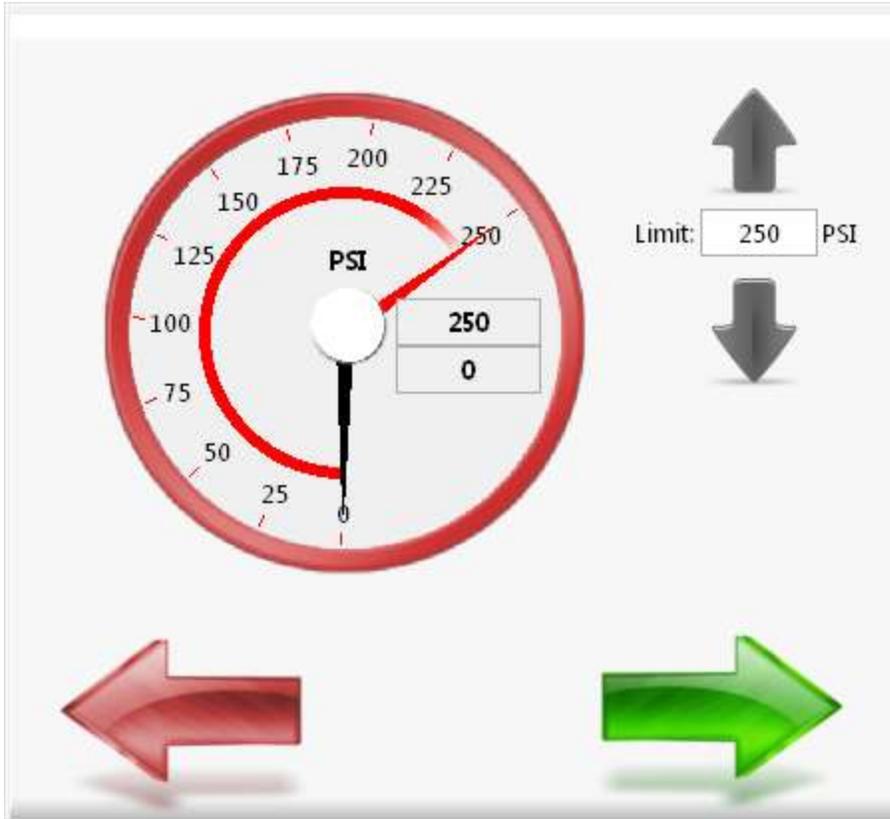
Figure 2. This screen is pressure setup screen that allows the operator to select maximum pressure setting for the pumps under that MFPC's control.
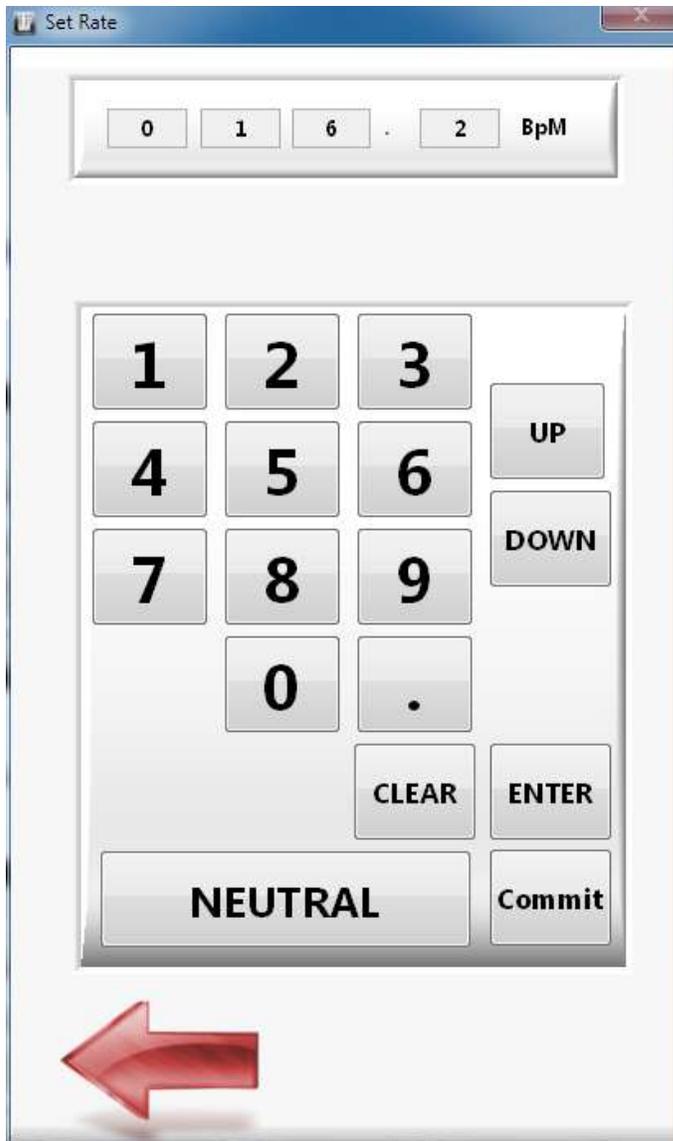
Figure 3. This screen is the rate screen that allows the operator to set a new rate and commit it to allow the rate to be transferred to the pumps.
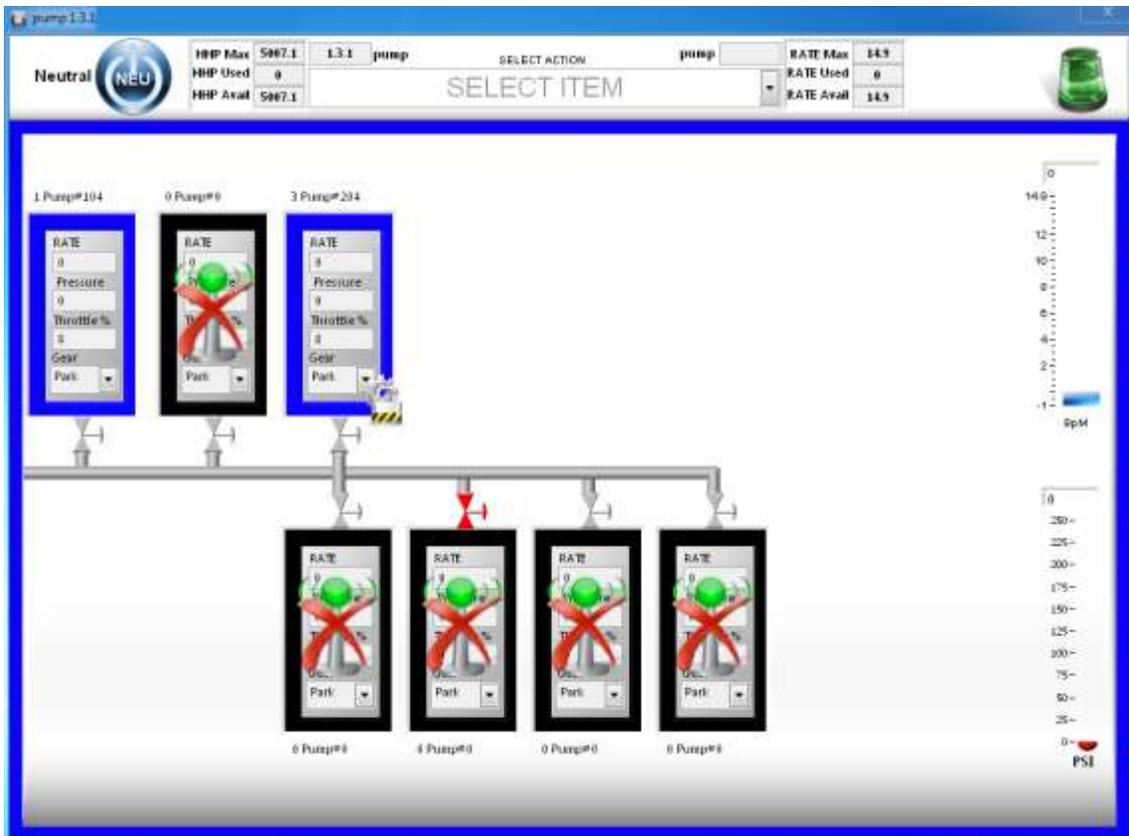
Figure 4. This is the main screen that shows the controls and active pumps along with a locked pump. The two pumps are in park with no output pressure or rate.
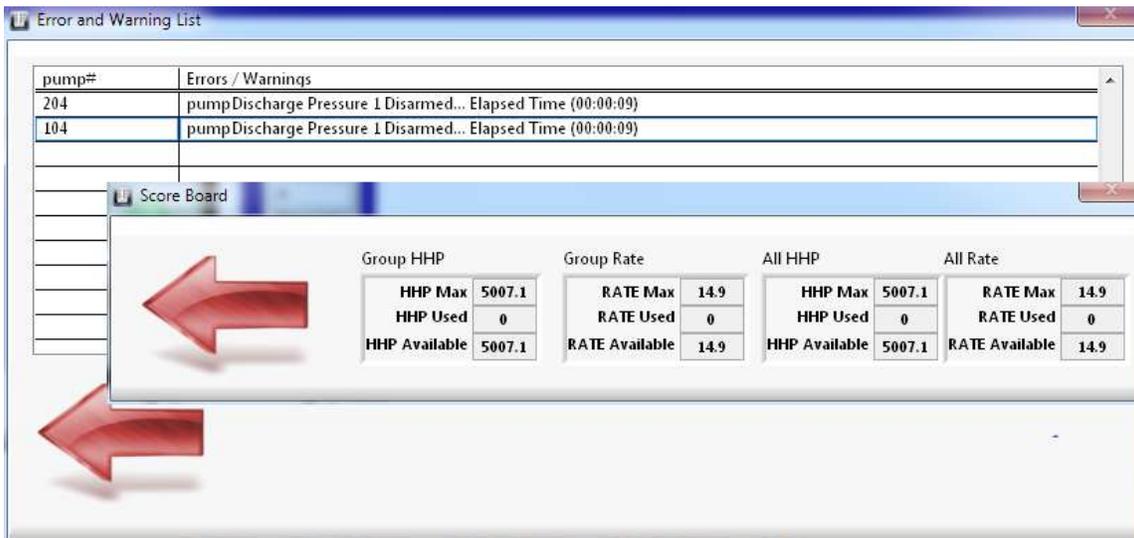

Figure 5. Above are the error and scoreboard screens. The warnings show an error on an emergency stop that has lost an input pressure signal. The scoreboard shows the total HHP and RATE for all pumps connected to the network while also showing grouped pumps.