High Throughput Screening System

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Products Used (See Figure 1 for System)
LabVIEW X.X w/ FlexMotion Package
NI PCI-7356 6-Axis Stepper/Servo Controller
NI PCI-6722 13-Bit, 8 Channel - Static and Waveform Analog Output Card
NI PCI-7342 2-Axis Stepper/Servo Controller
NI SCC-68 68-Pin Terminal Block with SCC Expansion Slots

The challenge
The challenge was to design High Throughput Screening System based on functional descriptions supplied by the customer. The system was based on a simpler prototype model developed previously for the customer by DSA. The first generation prototype system used only two axes of motion to move a target plate below a Sono-Tek spray nozzle. The spray from the nozzle was directed by nitrogen gas directed by a proprietary design gas distributor plate. The gas flow was controlled by an Aalborg gas mass flow meter.

The customer wanted to take the next step and upgrade the capability of the basic system into an OEM instrument. They contracted Data Science Automation, Inc. to perform the feasibility study and prototype system design. The desire was to add motion to the nozzle to allow fine tuning of the spraying process. This motion would be in addition to the motion of the targets on the X, Y stage.

Additional enhancements to the system were desired in regards to the fluid delivery system that supplies the sample fluid to the nozzle. In the original design a simple syringe pump and controller were used to deliver the sample fluid to the nozzle. The new solution would need the capability to deliver a constant no-pulse stream of fluid. To make the instrument even more capable it was desired to use a multi-stream selection valve to allow the user to run up to 6 different fluids in the system.

The final design specification called for the control of six axes of motion as specified by the customer and control of the fluid and gas delivery systems. In order to leverage the knowledge gained on the previous system the customer elected to use some of the same hardware.

The Solution

DSA leveraged National Instruments hardware and selected the PCI-7356 Six-Axis motion controller. The Primatics motor drive was selected for its ease of integration with

the NI motion control cards. No Universal Motion Interface is needed to connect the NI Motion card with the drive. Both the PCI-7356 and the MDC800 allow the user to control stepper motors as well as servo motors. Using the MDC 800 and the PCI-7356 reduced the number of hardware control pieces required for the system and helped to reduce the size of the final instrument.

The six axes of motion control are broken into 3 separate stages. The first controls the position of the target well plate. This is a simple XY linear stage comprised of Parker/Daedel 404XE linear stages with LV233 stepper motors. During the spraying operation this is the only stage that provides motion. The second stage controls the position of the spray nozzle. It is comprised of a Y, Z, and Rotary stage. The Y, Z stage is pinned just like the XY stage, but it mounted on a cross-member in the system above the XY stage. The rotary stage is a simple Apex Dynamics gearbox mounted using a simple bracket. The gearbox controls the angle of the nozzle spray.

DSA researched the available motors and stages including linear motor stages, rotary motion stages, servo motors, and stepper motors. We helped the customer select the lowest cost robust option that would exceed their motion requirements and allow ease of programming in the future.

(??)The spray system will operate in several overall modes. First and foremost will be the spray mode. One of the secondary modes is the wash mode. During the wash mode the nozzle is moved away from the spray area and over a system drain. The nozzle is then rotated to point downward into the drain.

The fluidics system was a new design that is completely different than the original prototype system. The original system utilized a syringe pump and syringe pump controller. The new system utilizes multiple selector valves and a continuous pump. The heart of the fluidics system was chosen for its unique ability to pump from 5-nL of fluid to 5-mL of fluid in a no pulse manner. Control of this valve is via a custom LabVIEW driver written by DSA. The valve pump is connected to the PC via an RS-232 serial cable.

DSA investigated multiple pump and valve technologies to determine which companies offered products that satisfied the customer requirements, while at the same time keeping in mind that each piece of the system would have to integrate with LabVIEW and National Instruments hardware. DSA was able to act as an informed agent for the customer, utilizing our knowledge of systems integration. Utilizing DSA to do this research allowed the customers scientists to concentrate on their core jobs and not have to take the time to learn about systems integration.

The valves in the fluidics system are manufactured by Rheodyne. They were selected based on their ability to handle the pressure in the system as well was their ease of integration with the NI hardware. The first 6-position, 7-port valve has the fluid head exposed to the user of the system. This allows them to place the 6 inlet tubes into sample or wash containers of their choice. The next valve is another 6-position, 7-port selector valve with four ports blocked, allowing the valve to be used as a two-way diverter valve. The next valve is a 2-position, 6-port unit that is used combination with the two-way diverter valve allow the user to alternate between loading the sample loop and emptying out to the drain, or pushing the fluid through the system to the spray nozzle.

Each of the valves has a built-in position control board and motor system powered by 24 VDC. Control of the 6-position valves is handled by what is described by Rheodyne as 4-channel Binary Coded Decimal logic. Four input channels allow the user to select the position of the valve by sending the appropriate coded position logic signals according to the following chart:

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Table 1 - 6-position, 7-port Valve Position Control Logic

Selector Valve Position	Connector J5 Logic Settings			
	J5-1	J5-2	J5-3	J5-4
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0

The 2-position, 6-port valve is controlled by simple line logic. Position 1 is selected by sending a logic high signal and position two is selected by sending a logic low signal. All of the valves in the system also communicate their state of operation, either done or busy as well as communicating if an error has occurred during a commanded move by setting the appropriate error feedback logic line to high.

The spray nozzle completes the fluidics system. This hardware was used in the previous version of the system. Sono-Tek provides a control box that allows the power of the ultrasonic atomizing signal to be controlled by LabVIEW. The Broadband Ultrasonic Generator, or BUG, has two differential analog input channels. The first channel is the external trigger channel that allows the user to turn the nozzle power on or off. The second channel controls the power applied to the nozzle. The power channel is a 0-10 VDC signal, where 1 VDC increment = a 2 Watt power increment at the nozzle.

The vaporized spray is directed towards the target by the Nitrogen gas plate. The flow of Nitrogen gas is controlled by an Aalborg Gas Mass Flow Controller. Control of this flow valve is through a differential 0-5VDC analog signal.

The final piece of equipment specified by the customer to be controlled by LabVIEW was an external HEPA filter that attached to the spray box using a three-inch diameter hose. The Sentry Air System model 200 Floor Sentry Hepa filter was selected based on its ability to provide low volume flow of 80 CFM or below. The Sentry Air Systems HEPA filters are not designed for external control, so a random-on solid state relay will be used to turn the exhaust fan on and off. The SSR control signal can range from 3-32 VDC.

The following table details the channel mapping for the system IO and which hardware. The Analog signals are connected to the PCI-6722 via the SCC-68. All the digital control for the valves is being handled by the general purpose digital IO available on the motion control card.

Table 2 – System IO Connections

Device	Input Signal	Output Signal	System Connection	Notes
Analog Control				
Aalborg Gas Flow Controller	0-5 VDC	-	AO 0 (PCI-6722)	control signal, scales 0-15L/min
Sono-Tek Nozzle	3-11 VDC	-	AO 1 (PCI-6722)	External Trigger (green/red wires)
	0-10 VDC	-	AO 2 (PCI-6722)	1 VDC increment = 2 Watt Power increment. External Power Adjust
Crydom SSR	TTL or 3-32	-	AO 3 (PCI-6722)	HEPA Fan control. Can use either TTL or Analog Signal

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	VDC			
Serial Communication				
Vici Pump M6	RS-232	RS-232	COM 1	Does not have LV driver
Digital IO Control				
Rheodyne 6-Inlet Stream Selector	4 DI	-	Port 1 Lines 0, 1, 2, 3	4 Line BCD (binary coded decimal) (from MDC)
	-	2 DO	Port 1 Lines 4,5	Done and Error
Rheodyne 6-Inlet Stream Selector (2 outlets)	4 DI	-	Port 2 Lines 0, 1, 2, 3	4 Line BCD (binary coded decimal) (from MDC)
	-	2 DO	Port 2 Lines 4, 5	Done and Error
2 Position 6-Port MHP9900-500-1	TTL	-	Port 3 Line 0	Low = Position 1, High = Position 2 (from MDC)
	-	2 DO	Port 3 Line 1	Status Feedback
		2 DO	Port 3 Lines 2, 3	Position Feedback
		1 DO	Port 3 Line 4	Error

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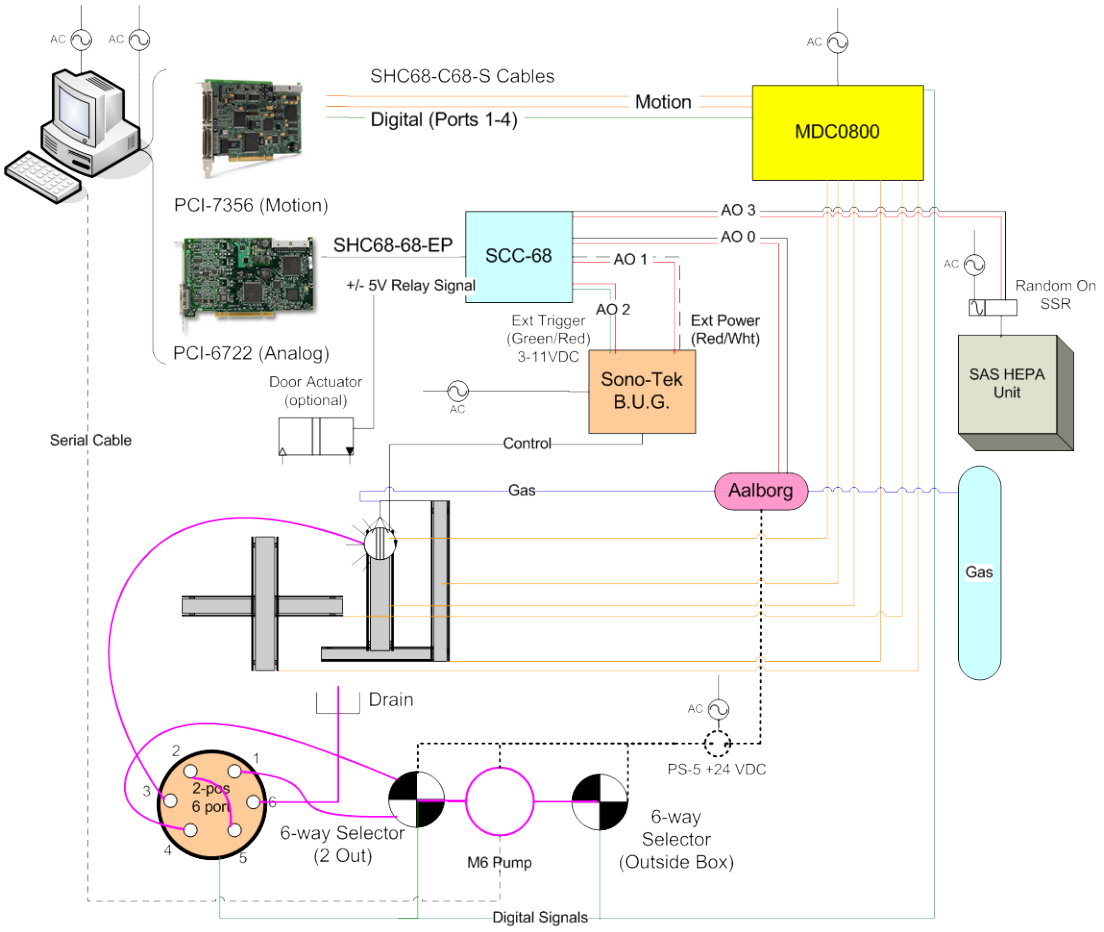

Figure 1 – System Schematic

Summary

This application expands the functionality of a previous testing application and creates an OEM instrument based upon National Instruments LabVIEW and NI Hardware. This system can be used to spray a multitude of target items with ultrasonically vaporized liquids.

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