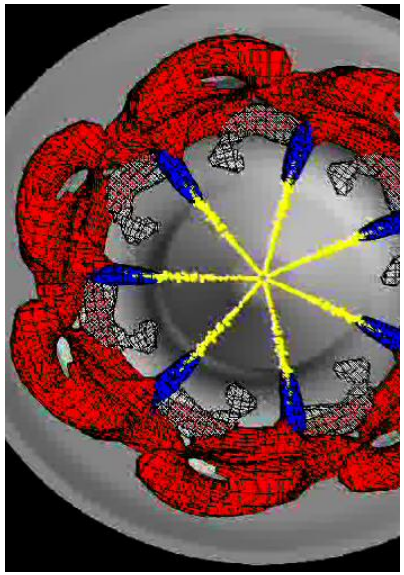
Internship Final Review

Fangzhou Xia

Fluid Metrology Group



About Me

Fangzhou Xia

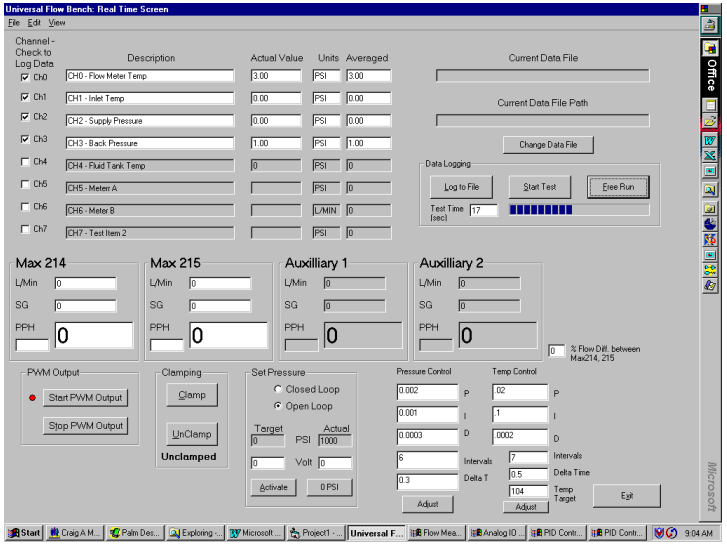
- School
  - **University of Michigan, Ann Arbor (UM)**
  - **Shanghai Jiao Tong University, China (SJTU)**
- Dual Degree
  - **Mechanical Engineering, B.S.E. (UM)**
  - **Electrical and Computer Engineering, B.S.E. (SJTU)**
- Expected Graduation Date
  - **May, 2015**
  - **August, 2015**

Project List

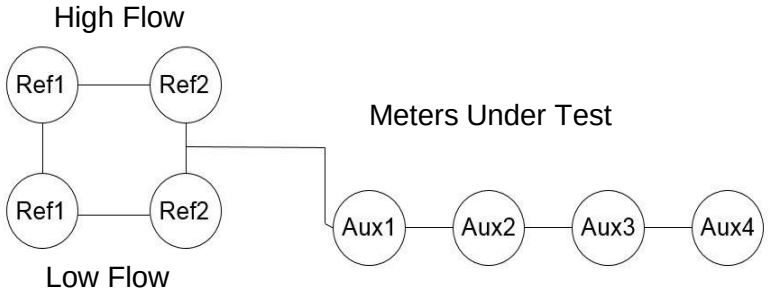
- Volumetric Prover Software Redesign
- Experiment Data Processing Automation
- Single Injector Tester Concept Proof
- Oil Prover Software Migration

Volumetric Prover Software Redesign

- Initial Status
  - Operational rig for calibration
  - Well-tested software
- Problem Identification
  - Software outdated (15 years)
  - Possible operational error due to user interface
  - Insufficient test capability
- Solution
  - Redesign Volumetric Prover software using LabVIEW



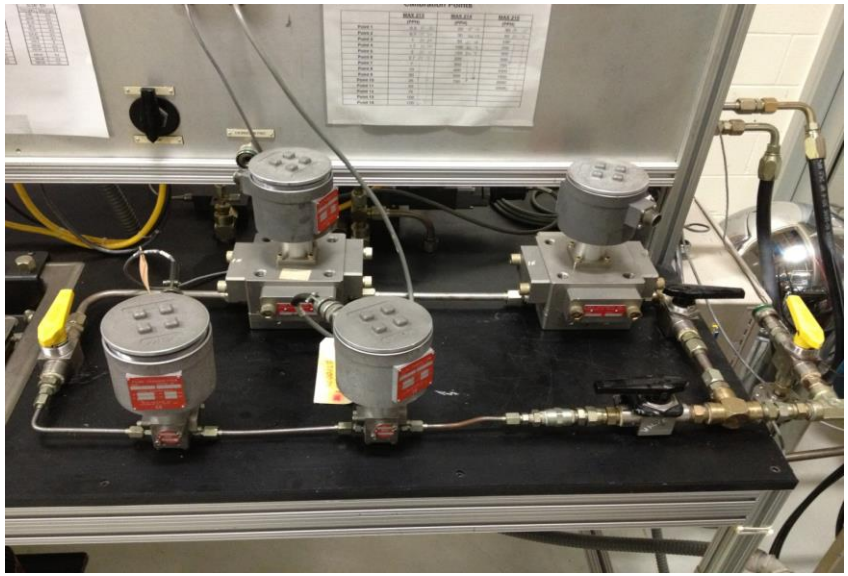
Original Volumetric Prover Software



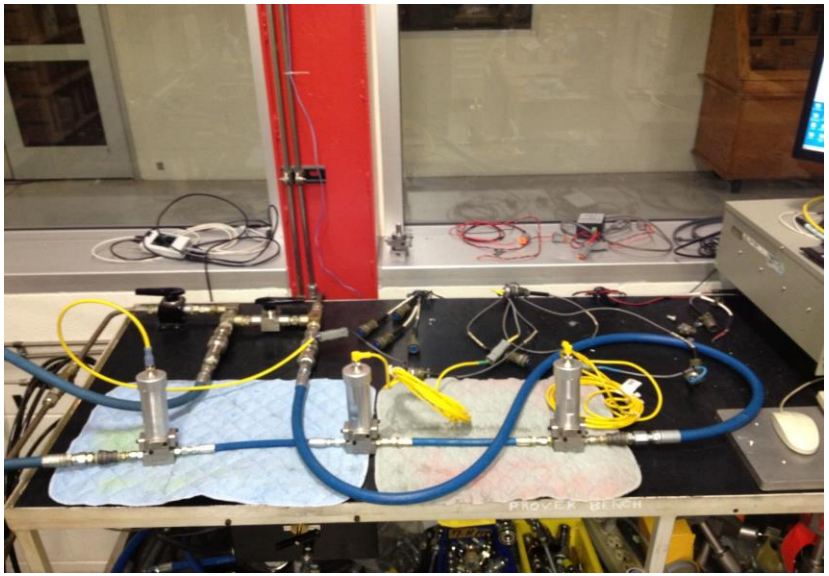
Original System Concept Diagram

Volumetric Prover Software Redesign

- Target Hardware Setup
  - 2 pressure sensors and 2 temperature sensors
  - 4 reference meters and up to 8 auxiliary meters



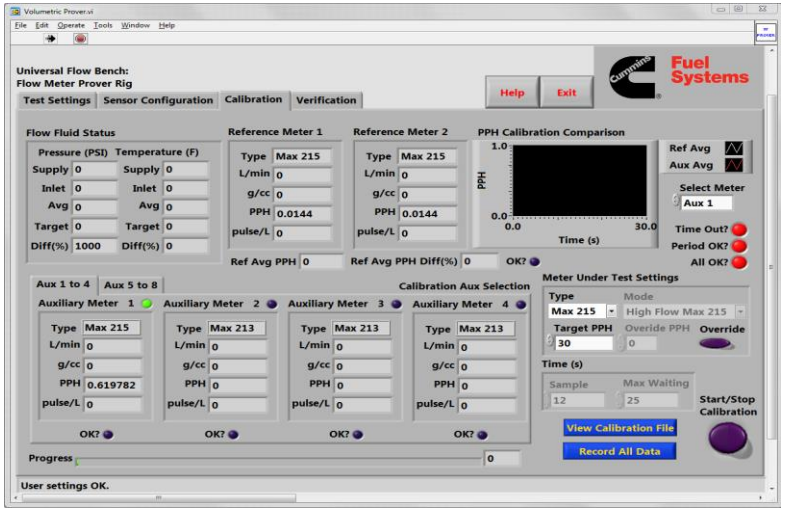
Reference Meters



Auxiliary Meters Under Test

Volumetric Prover Software Redesign

- Task Completion
  - Fully developed user interface for data processing
  - Adapted FPGA code for standard data acquisition
  - Electrically tested hardware connection
  - Developer, operator documentation

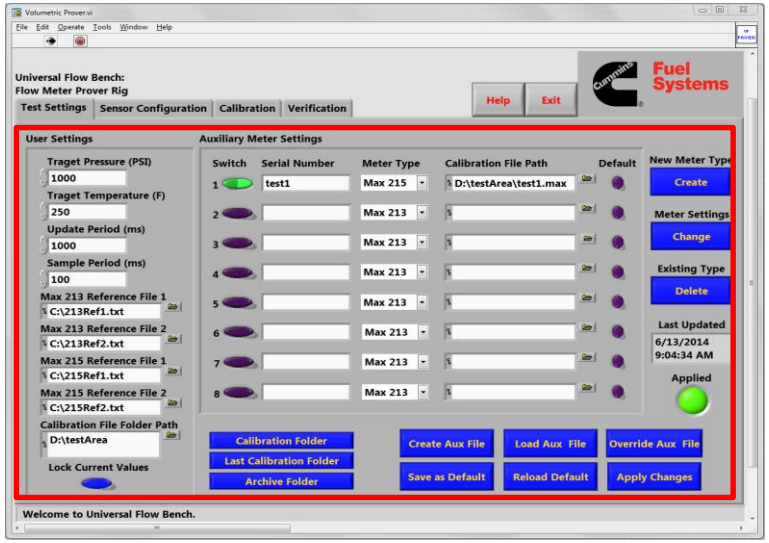


User Interface

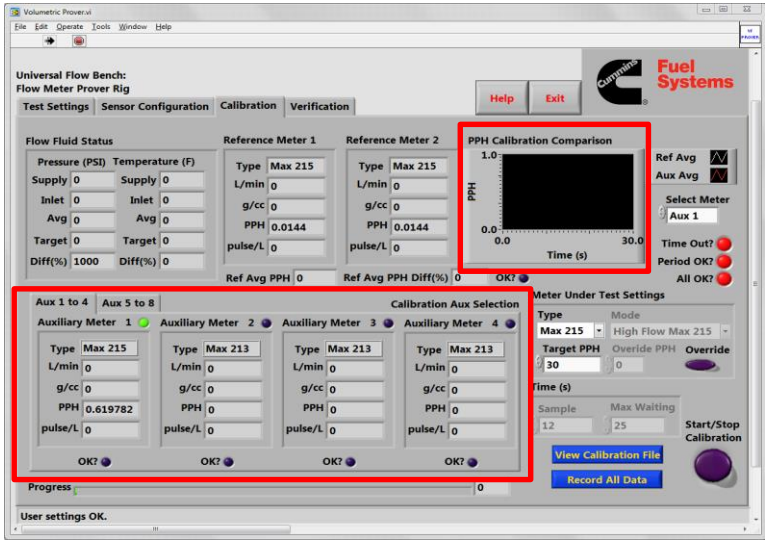
Documentation

Volumetric Prover Software Redesign

- Major Improvements
  - User friendly interface with drop down list for test configurations reducing operational error
  - Increased test capability with 8 channels
  - Real time measurement display for monitoring purpose



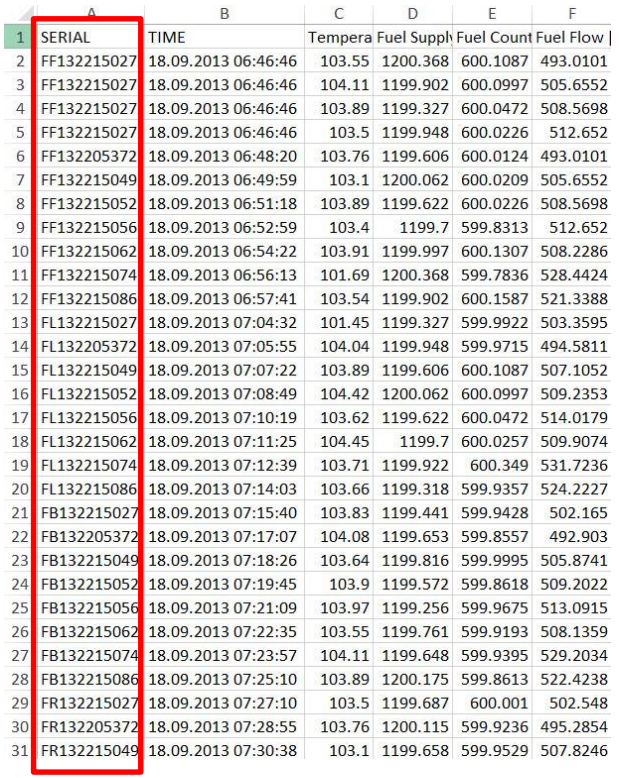
Test Configurations



Test View

Experiment Data Processing Automation

- Problem Identification
  - Experiment data for different meters are mixed together
  - Manually generating multiple graphs in Excel is inefficient
- Solution
  - Write VBA code to select data from multiple files
  - Automate graph generation process using VBA



	A	B	C	D	E	F
1	SERIAL	TIME	Tempera	Fuel Supply	Fuel Count	Fuel Flow
2	FF132215027	18.09.2013 06:46:46	103.55	1200.368	600.1087	493.0101
3	FF132215027	18.09.2013 06:46:46	104.11	1199.902	600.0997	505.6552
4	FF132215027	18.09.2013 06:46:46	103.89	1199.327	600.0472	508.5698
5	FF132215027	18.09.2013 06:46:46	103.5	1199.948	600.0226	512.652
6	FF132205372	18.09.2013 06:48:20	103.76	1199.606	600.0124	493.0101
7	FF132215049	18.09.2013 06:49:59	103.1	1200.062	600.0209	505.6552
8	FF132215052	18.09.2013 06:51:18	103.89	1199.622	600.0226	508.5698
9	FF132215056	18.09.2013 06:52:59	103.4	1199.7	599.8313	512.652
10	FF132215062	18.09.2013 06:54:22	103.91	1199.997	600.1307	508.2286
11	FF132215074	18.09.2013 06:56:13	101.69	1200.368	599.7836	528.4424
12	FF132215086	18.09.2013 06:57:41	103.54	1199.902	600.1587	521.3388
13	FL132215027	18.09.2013 07:04:32	101.45	1199.327	599.9922	503.3595
14	FL132205372	18.09.2013 07:05:55	104.04	1199.948	599.9715	494.5811
15	FL132215049	18.09.2013 07:07:22	103.89	1199.606	600.1087	507.1052
16	FL132215052	18.09.2013 07:08:49	104.42	1200.062	600.0997	509.2353
17	FL132215056	18.09.2013 07:10:19	103.62	1199.622	600.0472	514.0179
18	FL132215062	18.09.2013 07:11:25	104.45	1199.7	600.0257	509.9074
19	FL132215074	18.09.2013 07:12:39	103.71	1199.922	600.349	531.7236
20	FL132215086	18.09.2013 07:14:03	103.66	1199.318	599.9357	524.2227
21	FB132215027	18.09.2013 07:15:40	103.83	1199.441	599.9428	502.165
22	FB132205372	18.09.2013 07:17:07	104.08	1199.653	599.8557	492.903
23	FB132215049	18.09.2013 07:18:26	103.64	1199.816	599.9995	505.8741
24	FB132215052	18.09.2013 07:19:45	103.9	1199.572	599.8618	509.2022
25	FB132215056	18.09.2013 07:21:09	103.97	1199.256	599.9675	513.0915
26	FB132215062	18.09.2013 07:22:35	103.55	1199.761	599.9193	508.1359
27	FB132215074	18.09.2013 07:23:57	104.11	1199.648	599.9395	529.2034
28	FB132215086	18.09.2013 07:25:10	103.89	1200.175	599.8613	522.4238
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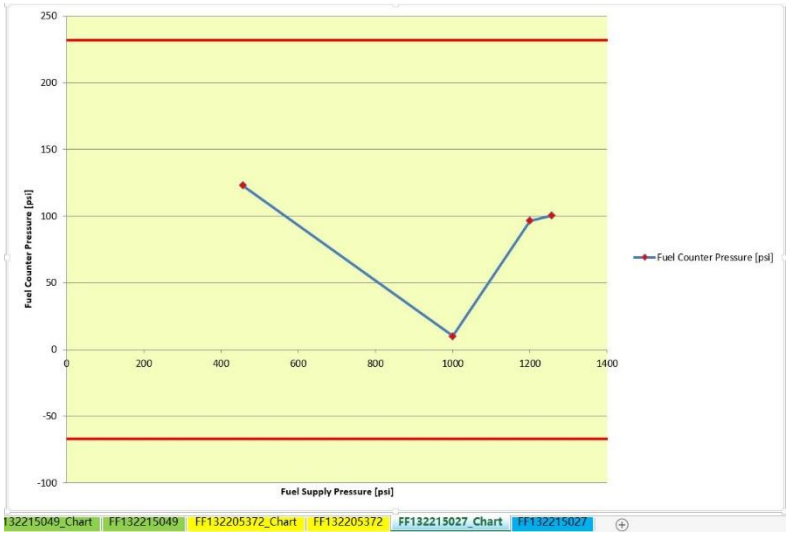
30	FR132205372	18.09.2013 07:28:55	103.76	1200.115	599.9236	495.2854
31	FR132215049	18.09.2013 07:30:38	103.1	1199.658	599.9529	507.8246

.csv File with Multiple Meters

Experiment Data Processing Automation

- Task Completion
  - Data selection based on user input with step-by-step instructions and configuration memory
  - Automated graph generation with control limits shown

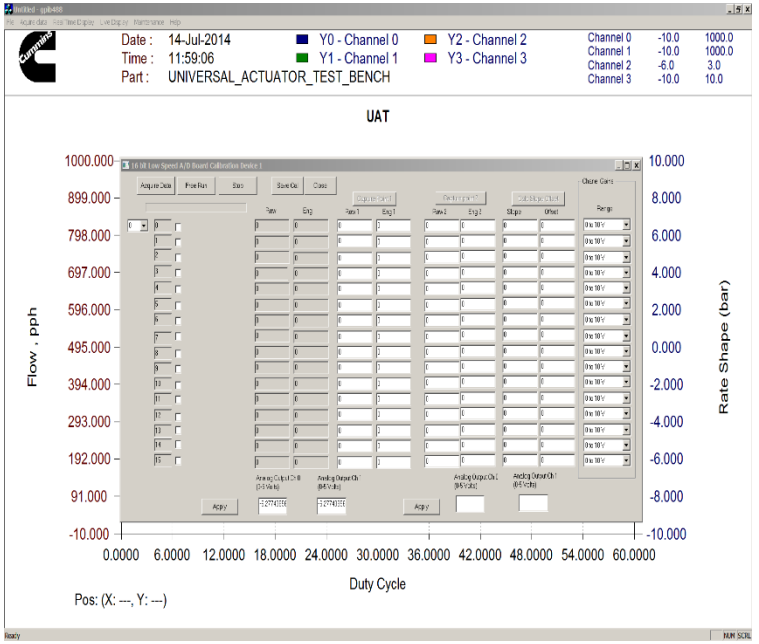
Data Selection User Interface



Data Plotting with Control Limits

Single Injector Tester Concept Proof

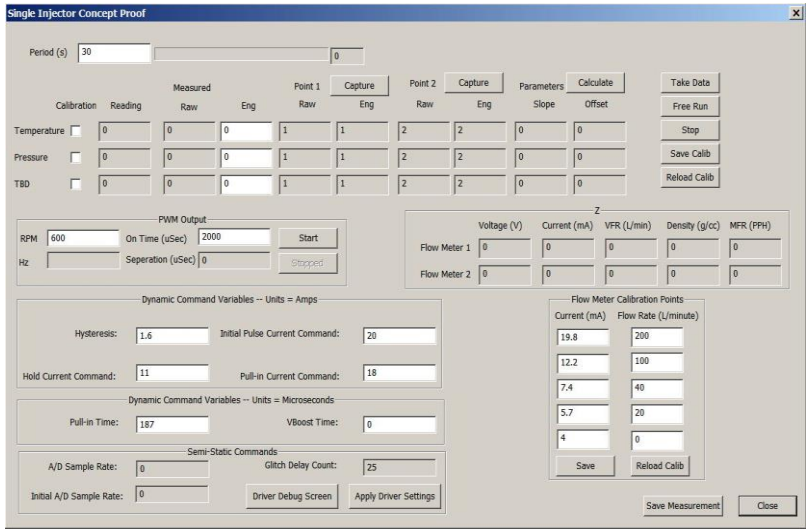
- Initial Status
  - Widely-used UHSDA software
  - Hardware available at FSP
- Problem Identification
  - Inefficient brought-back testing
  - No available cheap tester
- Solution
  - Design a single injector tester
- My Role
  - Conduct concept proof using parts of UHSDA



UHSDA Software

Single Injector Tester Concept Proof

- Task Completion
  - User interface with all parameters on the same screen
  - PWM output, RS 232 serial communication for injector driver, and analog sensor reading input
  - PLCs investigation for cost efficient implementation



User Interface

Injector Driver Hardware

Single Injector Tester Concept Proof

- Concept Proof Result
  - Feasibility confirmation of PC based single injector tester with current low level data acquisition mechanism
  - Significant price drop with PLC implementation can lower the cost for production

	2080 Micro820	1763 MicroLogix 1100	PicoGFX Controllers
Digital I/O	20	Up to 128	Up to 272
Analog Input	4	Up to 16	Up to 40
Analog Output	1	Up to 16	Up to 40
RS-232	1	1	None
EtherNet/IP	1	1	None
LCD Screen	1	1	1
I/O Expansion	None	Up to 4 1762 MicroLogix I/O	1760 Pico Expansion I/O

Rockwell Micro PLC Comparison

Proposed PLC Module

Oil Prover Migration

- Initial Status
  - Developed Volumetric Prover
  - Working viscor and oil rig
- Problem Identification
  - Lack analog flow meter inputs
  - Acquire data for both rigs
- Solution
  - Migrate the Oil Prover additional requirements to the Volumetric Prover software

Volumetric Prover Software

Oil Prover Migration

- Task Completion
  - Additional sensor input channels specified
  - Low level data acquisition test complete
  - User interface updating in progress
  - Software implementation and validation in progress

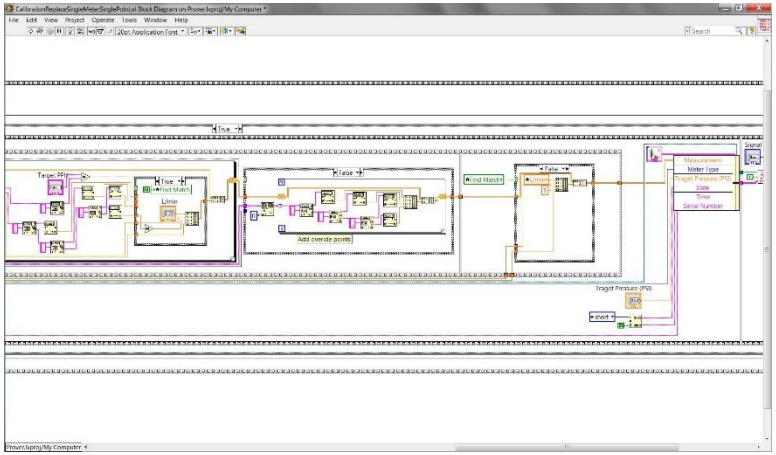
Volumetric Prover Cable Connection Instruction (Last Updated: Fangzhou Xia 7/8/2014)

Digital Input Connection					Analog Input Connection					Shared channel, need hardware rewiring for different test if channel used
Board	NI PCI-7813 R				Board	NI PCI-6259				
Cable	SHC68-68-RDIO				Cable	SHC68-68-EPM				
Pin Shield	SCB-68	#1			Pin Shield	SCB-68	#1			
Software Channe	Positive	Pin#	Negative	Pin#	Software Channel	Positive	Pin#	Negative	Pin#	
Max 213 Ref 1	DIO0	35	DGND	1	Supply Pressure	AI 0	68	AI GND	67	
Max 213 Ref 2	DIO1	36	DGND	2	Inlet Pressure	AI 1	33	AI GND	32	
Max 215 Ref 1	DIO2	37	DGND	3	Supply Temperature	AI 2	65	AI GND	64	
Max 215 Ref 2	DIO3	38	DGND	4	Inlet Temperature	AI 3	30	AI GND	29	
Auxiliary 1	DIO4	39	DGND	5	Analog Auxiliary 1	AI 4	28	AI GND	27	
Auxiliary 2	DIO5	40	DGND	6	Analog Auxiliary 2	AI 5	60	AI GND	59	
Auxiliary 3	DIO6	41	DGND	7	Analog Auxiliary 3	AI 6	25	AI GND	24	
Auxiliary 4	DIO7	42	DGND	8	Analog Auxiliary 4	AI 7	57	AI GND	56	
Auxiliary 5	DIO8	43	DGND	9						
Auxiliary 6	DIO9	44	DGND	10						
Auxiliary 7	DIO10	45	DGND	11						
Auxiliary 8	DIO11	46	DGND	12						

Oil Prover Cable Connection Suggesstion (Last Updated: Fangzhou Xia 7/9/2014)

Digital Input Connection					Analog Input Connection					Analog Input Connection				
Board	NI PCI-7813 R				Board	NI PCI-6259				Board	NI PCI-6259			
Cable	SHC68-68-RDIO				Cable	SHC68-68-EPM				Cable	SHC68-68-EPM			
Pin Shield	SCB-68	#1			Pin Shield	SCB-68	#1			Pin Shield	SCB-68	#2		
Software Channe	Positive	Pin#	Negative	Pin#	Software Channel	Positive	Pin#	Negative	Pin#	Software	Positive	Pin#	Negative	Pin#
[redacted]					[redacted]					Supply Pre	AI 0	68	AI GND	67
										Inlet Press	AI 1	33	AI GND	32
										Auxiliary F	AI 2	65	AI GND	64
										Back Pres	AI 3	30	AI GND	29
Auxiliary 1	DIO4	39	DGND	5	Analog Auxiliary 1	AI 4	28	AI GND	27	Supply Tei	AI 4	28	AI GND	27
Auxiliary 2	DIO5	40	DGND	6	Analog Auxiliary 2	AI 5	60	AI GND	59	Inlet Temp	AI 5	60	AI GND	59
Auxiliary 3	DIO6	41	DGND	7	Analog Auxiliary 3	AI 6	25	AI GND	24	Auxiliary 1	AI 6	25	AI GND	24
Auxiliary 4	DIO7	42	DGND	8	Analog Auxiliary 4	AI 7	57	AI GND	56					
[redacted]														
Max 214 Ref 1	DIO10	45	DGND	11										

Sensor Input Channel Specification



LabVIEW Code in Modification

Lessons Learned

- Team Work
  - Importance of following standards
  - Effective communication skill
  - Efficient learning
- Individual Work
  - On-time delivery
  - Embracing challenges
  - Enhanced technical skills
- Cummins
  - Great culture, numerous events, nice place to work

Q&A

Thank you!