Universal Control Simulator System

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Category
Automotive

Products Used
LabVIEW 7.0
MathWorks Simulink model
IPC Advantech Industrial PC
3 PCI 6602
5 PCI DIO96
2 UEI PD2AO32

The Challenge
Mack Trucks/Volvo has developed a new electronic truck architecture. In order to test the system components a new digital simulator needed to be developed to replace the existing analog simulator. The analog simulator was not capable of validating the interaction between all the Electronic Control Units (ECUs) and did not have the flexibility to test the wide variety of vehicle setups.

The Solution
Data Science Automation proposed a phased approach to design and develop a test simulator to validate and confirm performance of Mack's new electronic architecture. The application was run on an industrial computer with PCI cards to connect to the 255 channels of I/O. The application interfaced with a Mathworks Simulink vehicle model for simulated control of I/O. Individual screens were created for start-up, driving, vehicle model, simulator, Engine ECU, Vehicle ECU, anti-lock braking system, gauge cluster, simulator configuration, and setup configuration.

The Problem

The Universal Control Simulator allowed the customer to test and verify the vehicle control units without the expense of the actual vehicle and its many components. The simulator allowed the ECUs to be tested in many different scenarios in a controlled environment. The application had to be extremely flexible to allow for different control units and different configurations of the control modules. For example: The Engine ECU needed to interface to different engine sizes having different torque and horsepower curves. All I/O had to be configurable. The user had to be able to control model inputs and outputs via either user interface controls or external signals from the I/O cards.

The Solution

DSA developed a system that allowed the user to configure the entire application from an Excel spread sheet (Figure 1). The Excel configuration file was a simple user interface that allowed the user to select and configure all the I/O available. The type of control and indicator and where to place it on the screen was configurable. If applicable, the controls / indicators displayed the safe, warning , and danger ranges. The controls and indicators on the front panel were displayed using LabVIEW subpanels. This allowed for ease of configuration. The main user interface had tabs that allowed the user to have dedicated screens for specific purposes, such as a driving screen, and gauge cluster. This also allowed the application to be scalable and allowed easy organization of the many interfaces the user must manipulate. Each Subpanel's indicator and control could be used to interface the I/O, the model or even another control or indicator. The system also interfaced a fault control board that was a custom built isolation PCB. This allowed faults to be injected into any of the I/O (to and from the ECU) at anytime to test different fault scenarios.

Figure-1 shows the Configuration Interface.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Configuration File		12/31/2003							Save_to_txt_&_CLOSE				
2														
3	ECU Name	ECU PIN Name	ECU Pin Number	Title	Polarity	Units	Max	Min	Danger Range (Min)	Danger Range (Max)	Warning Range(Min)	Warning Range(Max)	Screen Location	Type
4	EECU	Low Range Indicator	PB18	Low Range Ind	AH	Din	1	0					0,0	LED
5	EECU	AC On/Off	PB21	testout	AL	Dout	1	0					0,1	Switch
6				Analogout		Aout	10	0	9	10	8	9	0,2	Dial
7				Manual_Vehicle_Speed_MPH		MPH	200	0	150	200	100	149	1,0	Knob
8				Manual_Switch_control			1	0	95	100	90	94	1,1	Switch
9				Accelerator Pedal		%	100	0	95	100	90	95	1,2	Knob
10				Road_grade			15	-15					1,3	Slide
11				Clutch_Switch_Control			1	0					1,4	Switch
12				Service_Brake_Switch_Control			1	0					1,5	Switch
13				Park_Brake_Switch_Control			1	0					1,8	Switch
14				Manual Engine Speed RPM		RPM	3000	0	2500	3000	2000	2500	1,9	Guage
15				Manual Engine Speed Switch			1	0					1,10	Switch
16				Mode_Switch			1	0					1,11	Switch
17				Start_Switch_Control			1	0					1,12	Switch
18				Axle_Carrier_Ratio			10	0	9	10	8	9	1,13	Knob
19				Tire_revolution_per_mile			1000	0	900	1000	800	900	1,14	Knob
20				Gear			5	1					1,15	Gear
21				Gear_Constant			5	1					1,16	Knob
22				Crank_RPM_out		RPM	3000	0	4000	5000	3000	4000	1,7	Meter
23				CAM_RPM_out		RPM	1500	0	2500	3000	2000	2500	1,18	Guage
24				Axle_Speed_out			2000	0	2500	3000	2000	2500	1,19	Meter
25				Crank Speed Out			5000	0	2500	3000	2000	2500	1,20	Meter
26				MPH_w_tire_size_tranny			200	0	180	200	180	160	1,6	Guage
27				Tail_Shaft_Speed			3000	0	2500	3000	2000	2500	1,17	Meter
28				Fault control		On = B	1	0					TOP	Switch
29	END			Cnt_out			1000	0	900	1000	800	900	0,4	Knob
30				Cnt_in			1000	0	900	1000	800	900	0,5	Guage
31				PCI6602_Dout	AH	PCI DO	1	0					0,10	Switch
32				PCI6602_Din		PCI DI	1	0					0,11	LED
33				PD2AO32_Din		PD2 DI	1	0					0,12	LED
34				PD2AO32_Dout		PD2 DC	1	0					0,13	Switch
35				Count_Out2			1000	0	1900	2000	1800	1900	2,0	Knob
36				Count_in2			2000	0	1900	2000	1800	1900	2,1	Guage
37				PCI6602_Dout2	AL		1	0					2,2	Rocker
38				PCI6602_din2			1	0					2,3	LED
39				PD2AO32_Dout2			1	0					2,4	Switch
40				PD2AO32_DIN2			1	0					2,5	LED
41				Test									3,0	Push Button
42				Test									4,0	Rocker
43				Test									5,0	Tank
44				Test									6,0	Thermometer

Figure 1 Configuration Interface

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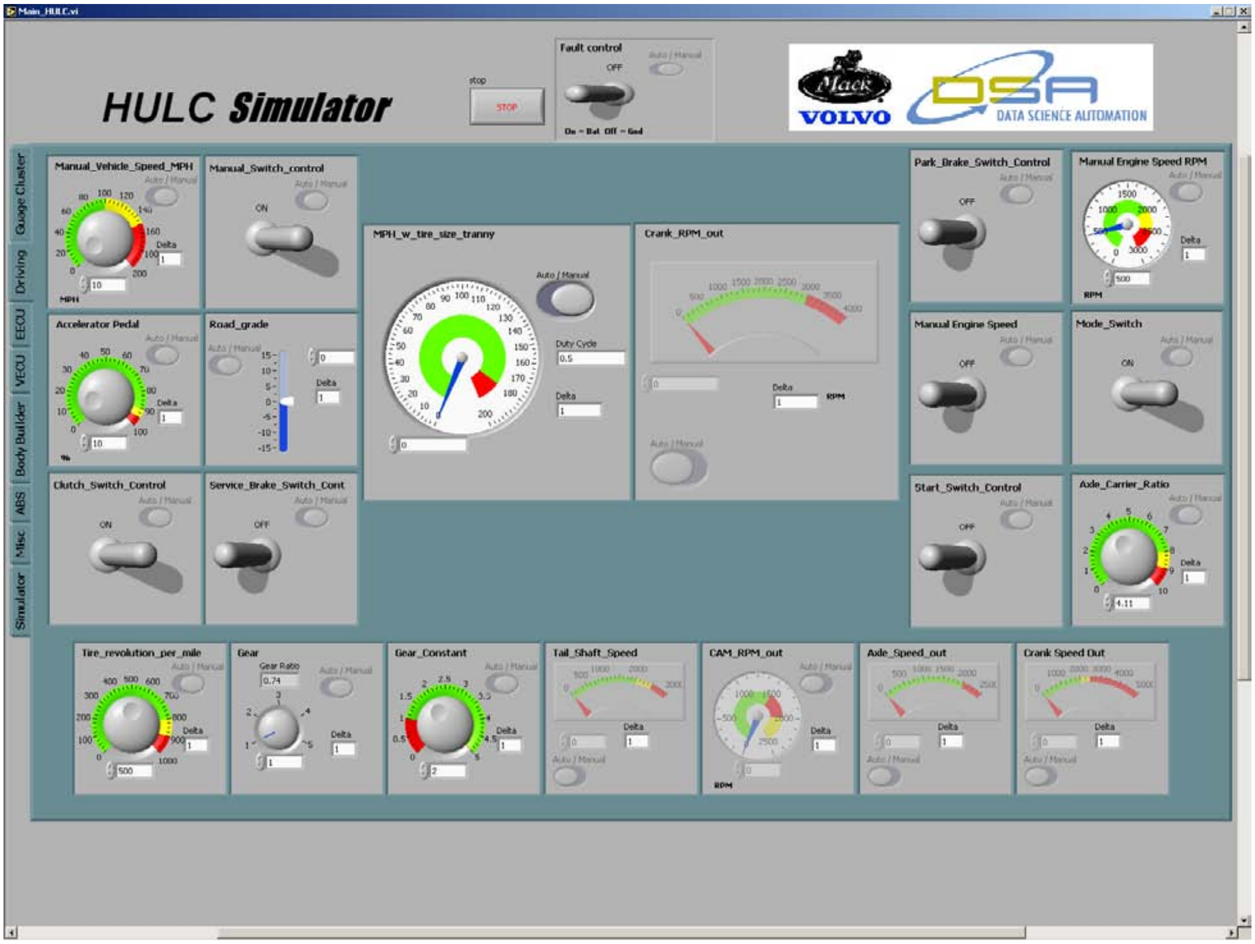

Figure 2 User Interface

The above figure depicts the user's driver screen. This screen was configured to interface the Simulink model. The inputs to the model could be sourced from both the front panel and the DAQ cards. The output of the model could be displayed on the front panel and also scaled and sent to the DAQ cards. When the user configured the I/O to have fault testing capabilities a fault switch would appear in the subpanel of the desired control or indicator. If no fault configuration was configured the switch was not visible. The auto / manual switch function allows the user to manually change the values that were sent to or from the model or to or from the DAQ outputs.

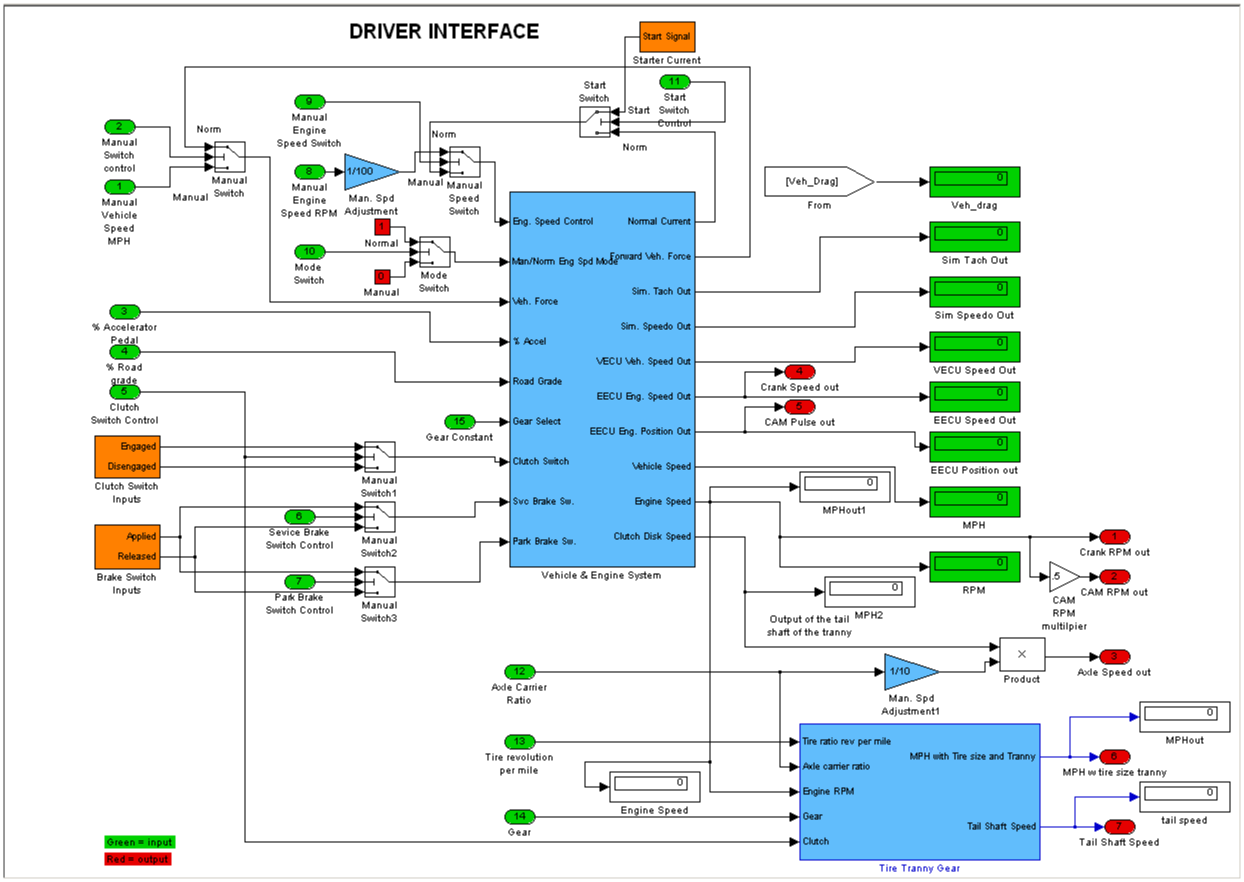

Figure 3 Mathworks Simulink Interface Front Panel

The above figure depicts the Simulink model; this model interfaced to LabVIEW via the simulation toolkit interface. A startup screen allowed the user to change Simulink models as desired. The model was originally developed to simulate the analog simulator. The model was adjusted and integrated into the LabVIEW application.

The Reward

This effort produced a fully integrated and automated control system capable of simulating and interfacing the ECUs that control all aspects of the vehicle. LabVIEW and the simulation toolkit interface in combination with several National Instrument DAQ cards and two third party multifunction DAQ cards enabled DSA to design a reliable, user friendly control system that was flexible enough to accommodate future enhancements in the application.

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