

1 TESTCELL[™] AUTOMATION AND DATA ACQUISITION SYSTEM



FIGURE 1 - TESTCELL[™] SINGLE LINE DIAGRAM

MAE is proposing our TESTCell[™] –data acquisition and automation control system which will be configured to meet and exceed the customer's specifications. This two-part high-performance control and data acquisition system is used for highly integrated test stands with high-speed test article data acquisition requirements and precision test stand control requirements.

The test stand control system will use portions of the established TESTCell[™] automation and data acquisition system. The TESTCell[™] system is an expandable control and data acquisition system used in the test cell environment. The system allows for interface and control to the test article, test article support systems, test stand, test stand support systems, test cell, test cell support systems and the facility. The TESTCell[™] Automation and Data Acquisition system is configured into two major components.

- 1. Automation controller with data acquisition (<=1,000 Hz sampling), DAC-32-2P-2IO
- 2. High-speed data acquisition system (up 44 GHz sampling) (optional), Customer supplied



1.1 Automation System Capabilities

- Vehicle electronic network interface: Automotive, truck, off-road, utility, aerospace, military, others. Sending and receiving vehicle data over the vehicle interface network(s) such as CAN, CAN-FD, ARC, MIL-STD-1553, others
- UUT sensor monitoring: Direct monitoring of sensors mounted to the test article to monitor: Temperature, pressure, flow, vibration, voltage, current, torque, speed, force, frequency, analog, digital, etc
- UUT physical interface actuator(s) with monitoring and control: Shifting, throttle, brake, clutch, ignition, others
- UUT sub-system and/or support component interfaces: Battery simulators, Battery/fuel cell management systems, DC chargers, DC/DC converters, fuel delivery and conditioning systems, coolant support carts, etc
- Test stand HV interface and control items: Multiple axis loading and regenerative motors and drives, gearboxes, electric & hydraulic movement systems, fans & blowers, etc
- Test cell interface items: Lighting, safety fencing, thermal climate system, exhaust emission analyzers & sampling systems, wind tunnels, antennas, receivers, altitude simulation systems, etc
- Facility & utility interface: Fire suppression systems, electrical power monitoring systems, fuel delivery systems, chilled water systems, HVAC systems, etc

1.2 High-Speed Data Acquisition System Capabilities

- DVM & analog sensor sampling (high-speed): up to 200 MS/s, 14 bit, 40 MHz bandwidth
- DVM & analog sensor sampling (ultra-high-speed): up to 12.5 GS/s, 8 bit, 5 GHz bandwidth.
- Communications: CAN, CAN FD, ARINC 429, MIL-STD-1533
- Power analyzer systems: Sampling up to 2.5 MHz with transmission to software & 10 MHz internally on analyzer.
- Sound and vibration systems: Sampling up to 204.8 kHz (typical 51.2 kHz). Sampling rate speeds are dependent on customer test requirements and sensor capabilities.
- Infrared thermal imaging cameras: Sampling 10 fps @ 512 x 256 pixels (dependent upon selected camera, and customer's visible field requirements). Thermal imaging is not performed at high speed.
- High speed camera: Sampling 120,000 fps @ 512 x 256 pixels or 20,000 fps @ 1024 x 1024 pixels, (dependent upon selected camera, and customer's visible field requirements).
- Antenna frequency range: Frequency range up to 44 GHz range with 1 GHz bandwidth and a tuning resolution of 4.45 µHz. Other frequency ranges and sampling bandwidths are available based on customer requirements



2 **TESTCELL SOFTWARE PACKAGE**

The TESTCell software is one of MAE's highly versatile software packages that is used to control, display and acquire data for transmission and powertrain test stands. The software is configured to operate the test stand based on the test stand requirements. This versatile software package consists of many configurable modules, which gives the customer full control and monitoring of their test stand. MAE will do the initial heavy lifting of configuring the TESTCell software package to the new test stand. MAE will then train the customer on how to use the different modules and how to calibrate signals and configure automated tests. The collected data can be saved internally to the hard drive or saved to a file server.

MAE's software is specifically designed for use with MAE's complete line of drivetrain dynamometer systems. The customer may customize MAE's software to exactly match the testing requirements. The MAE software provides continuous real time computer monitoring of all critical system parameters and real time data acquisition of critical parameters that may be used to form custom printed tabular and graphical reports of the results of the test procedures. MAE's software is a Microsoft Windows[©] based operating system and is a state-of-the-art data acquisition system.

Functionally, the system provides for manual operation of the test stand and allows the operator to record data at will. The system can also operate in a "semi-automatic" mode which prompts the operator through the test sequence and the system then performs "auto-speed / auto-loading". In either case, the test stand compares specified test values to actual values and acquires, logs, and records test data to a disk drive for permanent record and/or printed record.

MAE's dynamometer software is a mature testing software package used by the following:

- military units for repair validation testing
- military suppliers for repair validation testing
- drivetrain remanufacturers
- drivetrain production facilities.

All functions listed are operator selectable through the advanced operator interface to allow full functionality of the test stand while displaying all required testing and user defined data.

The Display Screen is completely configurable by the operator. MAE has supplied a library of gauges, charts, digital display, bar graphs, etc. to allow the operator to configure, save and recall a display screen.

The operator can assign different channels to the displays, filter channels, engineering units as well create new data channels. New channels such as math channels can be developed by using mathematical operations on existing channels to create new channels. The data gained from these new channels can be displayed, saved and reviewed like any other system channel.





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FIGURE 2 - MAIN TESTING SCREEN

The main testing screen is the full-screen form that is displayed immediately upon login. From the main testing screen, all software functions can be accessed using the main menu. To log out of the software and return to the login screen, select the 'Log Out' menu option on the right side of the menu.

The 'Test Modes' menu allows the operator to select the testing mode. The testing modes are 'Manual (Constant Target)' and 'Scripted'. Please see the section 'Test Modes' for more information on the testing modes.

The 'Utilities' menu contains items which can be used to access the various utilities discussed in the 'Utilities' section of this document.

The 'Settings' menu allows access to the various configuration parameters of TESTCell. See 'Settings' for more information.

The main testing screen contains a row of tabs, labelled "Display 1" through "Display 5", that can be used to auto-switch between 5 different user-defined display panel configurations. Each fully-configurable display panel is used to represent the values relevant system channels using an assortment of different display controls. The display panel is discussed further in the Display Panel section of this document.



2.1 Test Modes

Manual (Constant Target) Testing – Allows on-the-fly testing, where the operator is presented with a test panel containing target sliders to control the throttle controller and power absorption unit (PAU). Note each test stand is different and a power absorption unit could be an eddy-current or an electric motor.

Upon being placed in constant target testing mode, the constant target test panel will be displayed. In order to make the target sliders active and enable the throttle controller and power absorbers, the operator must click the green 'Start Test' button.

The dropdown boxes are used to set the control mode for the throttle controller / PAU. Control modes include speed, where target points are specified in terms of RPM, torque (Ft. Lbs.), power (HP), and manual (open-loop, 0-100%). Output PAUs will also have available Vehicle Simulation (Polynomial Loading) mode, where target output torque load is calculated as a function of engine speed (Torque = $A + Bx + Cx^{2}$, where x is input speed). Ramp rates for each control mode (RPM/Sec, Ft. Lbs./Sec, HP/Sec, %/Sec), vehicle simulation A, B, and C constants, simulated inertia, and slider minimum and maximum reference values can be set on the 'Manual Test Parameters' screen, available from the 'Settings' menu.

While actively testing, each slider can be used to specify the target point, or a specific target value can be typed in the value box and the 'Enter' key pressed. Once the desired input and output modes have been selected and appropriate target points have been defined, the operator clicks the blue 'Apply' button to send these values to the test stand controller.

At any time before, during, or after a constant target test, the operator can start a data acquisition session by clicking on the dataset status on the status bar at the bottom of the main screen and selecting 'Begin Manually Recording' from the context menu (the operator will be prompted for a filename for the new dataset). The same menu can also be used to stop and save the recording session.

When constant target testing is complete, the operator clicks the red 'Stop Test' button, which disables the mode dropdowns and target sliders ends the test. The throttle controller and power absorber will also be disabled.



FIGURE 3 - CONSTANT TARGET TEST PANEL



Scripted Testing – Allows the operator to execute scripted tests created using the Script Editor (discussed in the 'Utilities' section of the document).

Upon entering scripted mode, the operator will be asked to enter some information on the scripted test parameters screen, such as test article identification, number of script iterations to run, and whether to automatically acquire data/report and add it to the database.

Scripted Test Parameters			
Operator	SUPER	Date/Time Run	10/7/2015 3:30 PM
Test ID	TEST-00051	Serial Number	45345423-1
# Of Iterations	1:	Part Number	A7885 ~
Script	Cell - Case New Hollar	nd\bin\Debug\Script	ts\blank.SCP Load
🔵 Add D	ataset to Database	🔵 Add Repo	ort To Database
DataSet Locati	on :R_TEST-00051_4	5345423-1_A7885_	10_07_2015_15_30.DS
Report Locati	on ≀_TEST-00051_45	345423-1_A7885_1	0_07_2015_15_30.PDF
	Done	C	ancel

FIGURE 4 - SCRIPTED TEST PARAMETERS SCREEN

After verifying the information on the scripted test parameters screen and clicking 'Done', the application enters scripted testing mode, where the scripted test panel is visible at the top of the main screen. Click 'Start Test' to begin execution of the selected script.

During the execution of a scripted test, the scripted test panel will display the current iteration, current step name, current step description, and time remaining in the current step. To get a detailed display of the control modes and target values for the current script step, hover the mouse over the step description display. While a scripted test is in process, the yellow 'Pause' button can be used to temporarily halt a running script, maintaining current control modes and target values, and the blue 'Advance' button can be used to manually increment a script to the next step before the specified step time expires or the break criteria are met. A scripted test can be aborted at any time before completion by clicking the red 'Abort Test' button.



FIGURE 5 - SCRIPTED TEST PANEL

After a scripted test has been completed, the operator will be presented with the test report, which contains all of the recorded values and pass/fail results for each step defined in the script. After reviewing the report, click 'Exit' on the report viewer screen to dismiss the report, which will be automatically saved to the database, and return to the main screen. At this point with the application still in scripted testing mode, the operator can click 'Start Test' to re-run the currently selected script test again. To select a new script to run or change any of the scripted test parameters, the operator must re-enter scripted testing mode from the 'Test Modes' menu.



2.2 Utilities

System Channel Editor – For operators of high access level, this menu item displays the *Diagnostic Display of System Data*, which is discussed later in this document.

Script Builder (Scripted Test Editor) – A utility for designing automated test routines. Each script consists of a number of sequential steps, and each step is defined by name, time, description, control modes, target values, ramp rates, conditional stepping (break) parameters, operator prompt, and a set of recorded channels with associated pass/fail criteria.

Step Name – The name of the step, which appears on the screen during execution, and on the report for any channels recorded during the step.

Step Time – The time, in seconds, of the step. Selecting infinite

Throttle Controller / Power Absorber Control – Select the control mode, target value, and ramp rate for the step.

Conditional Stepping – To use conditional stepping, select "Break On Channel Value". Select the channel, the operation (greater-than or less-than), the value, and the break action. When selected, if the value of the break channel meets the break criteria during execution of the step, the script will perform the selected break action (Jump To Next Step, Jump To Step #, Jump To Next Iteration, or End Script). Note that when conditional stepping is selected, the step time is still in effect, acting as a timeout for the break action. If the time expires before the break criteria have been met, then the script simply proceeds to the next step, and the break action is not preformed.

Step Description – The text that will appear in the scripting status during the execution of this step.

Use Operator Prompt – If selected, then an operator prompt dialog displaying the text will appear on screen at the beginning of the step, and the script will advance to the next step only when the operator clicks the 'Continue' button on the dialog. When the operator prompt option is selected, both the step time and conditional stepping are disabled.

Reported Channels – Specify the channels to be recorded on the report for this step. For each channel selected, select the value type to record. The snapshot value type records the value of the channel at the conclusion of the step, the mean value type records the average value of the channel throughout the step, and minimum, and maximum record the minimum and maximum values of the channel throughout the step. Also, high and low pass/fail criteria can be entered for each channel. After execution, if the recorded value does not fall within the bounds of the high and low limit, then the channel will appear with a red background on the test report, signaling a failure.

A button bar across the bottom of the script editor contains several functions.

Load/Save Script – Recall from and save the current script to disk.

Clear Script – Clear the contents of the currently loaded script and reinitialize the script builder with a blank script.

New Step – Adds a new step to the end of the currently loaded script.

Remove Step – Removes the currently selected step from the script.



Copy/Paste Step – Copy and paste a step from one part of the script to another. Note that a pasted step will come in sequence after the selected step.

Exit – Dismiss the script editor and return to the main screen.

Scripted Tes	st Editor												
Step #	Step Name		Throttle Cont	rol			Power Absor	ber Control					
1	Step Name Step Name		Mode	Speed	~		Mode	Torque			\sim		
3	Step Name	Step Number	Setpoint	2000.00		RPM	Setpoint	250.00				Ft Lbs	
4	Step Name		Ramp Rate	500.00		PDM/Sec	Ramp Rate	50.00				Et Ibe /	Sec
5	Power Run	5				IVFIN/36C						T C. ED3./G	
		·	Conditional S	stepping	Break Channel	Oper	ation	Value	В	reak Action			
		Step Name	Break On	Channel Value	Coolant Temp (°F)	~ <=	>=	175.00 °F	Advance	To Next Step) ~		
		Power Run					Rep	orted Channels					
			Step Desc	cription	Power Run			Channel		Value Type	e Hig	h Low	^
		Step Time (sec)			Operator P	rompt	Thr	ottle Pos (%)	5	Snapshot	~ 50	60	
		100.00 🗌 Infinite			•	•	Tot	al Power (HP)	N	Maximum	~ 125	150	
			Use Ope	erator Prompt			Fue	el Flow (Gal)	N	lean	~ 2	3	~
_				,				Add/R	temove Repo	orted Chann	els		
Load	Script	Save Script	Clear Scrip	ot New	v Step	e Step	Copy Ste	p Pas	te Step		E	kit	

FIGURE 6 - SCRIPT BUILDER SCREEN

Test Record Database – Displays a utility which allows previous test records to be recalled and to view the datasets and/or reports associated with those test records. The list of saved records can be sorted in ascending or descending order by clicking on the column headers. To search for one or more test records with specific properties, enter the search criteria in the boxes below each column. The list will automatically filter as the search criteria is entered. To view the dataset (using the Dataset Viewer utility, discussed in length in the section of this document labelled "Dataset Viewer") or report (using Adobe Reader) associated with a test record, select the record by clicking on it, then click either the 'View Report' or 'View Dataset' button. If a selected test record does not have an associated dataset or test record available in the database, then the button for that function will be disabled. This utility is available only to operators with a medium access level or higher. Once finished, click 'Exit' to dismiss this utility and return to the main testing screen.

Test Record Database				
Operator	Test ID	Serial Number	Part Number	Date/Time Run
jerstilla	TTTT1234	SNSN3334433444	PN98798	09/21/15, 02:53 PM
MAEACCESS	TEST-00015		A7885	10/02/15, 02:23 PM
MAEACCESS	TEST-00041		A7885	09/25/15, 02:43 PM
MAEACCESS	TEST-00041		A7885	09/25/15, 02:44 PM
SUPER	T-TEST117	SN78687CCF-1210	pn889762394c	09/21/15, 12:27 PM
SUPER	T1006-2-1	SN876349-10023	pn98745987ac	09/21/15, 01:37 PM
SUPER	TED8763459	SN87364-100384	pn8756c7c5	09/21/15, 12:48 PM
SUPER	TEST-00042		A7885	10/01/15, 01:36 PM
SUPER	TEST-00042		A7885	10/01/15, 01:37 PM
SUPER	TEST-00043		A7885	10/01/15, 01:39 PM
SUPER	TEST-00044		A8683	10/01/15, 01:50 PM
SUPER	TEST-00045		A8683	10/01/15, 01:53 PM
SUPER	TEST-00046		A8683	10/01/15, 01:55 PM
SUPER	TEST-00047		A8683	10/01/15, 01:58 PM ~
				Before After 10/07/15, 03:54 PM ≑
View R	eport	View Data	set	Exit

FIGURE 7 - TEST RECORD DATABASE CONFIDENTIAL



Dataset Viewer – Generally used for datasets recorded manually, this menu option opens a file dialog that allows the operator to select a dataset from disk to load into the Dataset Viewer utility, discussed in another section of this document. Note that the Dataset Viewer can be launched for automatically-recorded datasets from the Test Record Database as well.

Dyno Calibration – To calibrate the torque measurement devices such as load cells and inline torque sensors, the dyno calibration utility is used. This utility is capable of doing both bipolar calibrations (when both positive and negative torque are measured, used with inline torque sensors and electric motors) and unipolar calibrations (for load cells, where torque is only measured in one direction). To begin a calibration, select the calibration channel from the dropdown menu. Then, install the calibration arm on the test stand (on the positive torque side if doing a bipolar calibration) and click 'Zero' to record the zero voltage (with calibration arm installed, so that any torque added by the weight of the calibration arm itself can be accounted for). Then, put the calibration weight on the calibration arm. If doing a bipolar calibration, click 'Positive Span', move the calibration arm and weight to the negative torque side of the test stand, and click 'Negative Span', otherwise, for unipolar calibrations, just click '+/- Span'. Finally, remove both the calibration weight and arm from the test stand, and click 'Zero' to re-record the zero voltage. To save the recorded calibration values to the dyno controller, click 'Save To DAC'.



FIGURE 8 - DYNO CALIBRATION UTILITY

PID Editor – The PID editor can be used to change the response characteristics of the test stand's input and output devices by changing the proportional, integral, and derivative constants of the device's control loop, as well as the minimum and maximum reference voltages. Typically, the devices are tuned for proper response prior to installation, and therefore this utility should only be used by trained individuals, as damage to equipment and personnel can result from an improperly tuned device.



Operator Database – This utility is only accessible to one account, the super user, which has the operator's name "SUPER" and the password "SUPER". This utility allows the super user to edit the operator database – add and delete operator accounts, change operator access levels, and change operator passwords. To add a new operator to the database, click 'Add New' and enter the operator's name, password, and access level under 'Operator Properties'. To edit the name and password or change the access level of any operator, select the operator by clicking on the name of the operator in the list on the left, and change the value of the fields in the box on the right. To delete the selected operator, click the 'Delete' button. To save the operator database to disk, click the button labeled 'Save', and click 'Exit' to close this utility.

Operator Database				
MD821447 MD814617	^	Operator Properties		
MD819460 MD877145		Operator Name	MAE447863	
MAE461170		Password	Mustang	
MAE423919 MAE461708		Access Level	Medium	~
MAE447863	× 1			
Add New	Delete	Sa	ive	Exit

FIGURE 9 - OPERATOR DATABASE

System Settings – Various system configuration settings, including those pertaining to hardware communications, disk locations of saved records, script files, and display panel configurations, can be set here. The display panel tabs on the main screen can be associated with display panel configurations on disk in the 'Display Panel' tab. Different items will appear here depending upon the configuration of the test stand.

System Settings	
Communications File Locations Display Pa	nels Automatic Testing Miscellaneous
Dyno Communications Active COM Port COM3	DI1 DI2 DI3 DI4 DI5 DI6 DI7 DI8 DI9 DI10 DI11 DI2 DI3 DI4 DI3 DI4 DI5 DI6 DI7 DI8 D09 DI10 DI11 DI2 DI3 DI4 DI5 DI6 DI7 D08 D01 D02 D03 D04 D05 D06 D07 D08
Connected	DO # 1 📩 Set Clear
Save And Exit	Cancel

FIGURE 10 - SYSTEM SETTINGS



Manual Test Parameters – Allows the operator to specify ramp rates, vehicle simulation constants, and maximum and minimum references pertaining to the manual (constant target) testing mode. The save any changes, click 'Save And Exit', otherwise, click 'Cancel' to dismiss this dialog without saving.

Manual Test Parameters		
	Throttle Controller	Power Absorber
Manual Ramp Rate (%/Sec)	10	10
Speed Ramp Rate (RPM/Sec)	100	100
Torque Ramp Rate (Ft. Lbs./Sec)	25	25
Power Ramp Rate (HP/Sec)		10
Vehicle Sim A Term		0
Vehicle Sim B Term		0.5
Vehicle Sim C Term		1
Vehicle Sim Inertia		1
Manual/Position Mode (%) Max Reference	100	100
Manual/Position Mode (%) Min Reference	0	0
Speed Mode (RPM) Max Reference	4000	4000
Speed Mode (RPM) Min Reference	0	0
Torque Mode (Ft. Lbs.) Max Reference	500	500
Torque Mode (Ft. Lbs.) Min Reference	0	0
Power Mode (HP) Max Reference		300
Power Mode (HP) Min Reference		0
Save And Exit	Cano	el

FIGURE 11 - MANUAL TEST PARAMETERS

Dyno Parameters – Set various configuration settings pertaining to the test stand. The items on this screen are set to appropriate values prior to installation, and generally are only accessed by trained personnel when required for maintenance or troubleshooting, or if any changes are made to the configuration of the test stand.

Dyno Parameters
Page 1 Page 2 Page 3 Page 4 Page 5 Page 6 Page 7 Page 8 Page 9 Page 10
Engine Turns Backwards
Fault If Engine Turning Backwards
Allow Start At Zero Speed
Torque Volts Plus With Pos Torque
PAU Torque PID Uses Total Torque
Engine Torque PID Uses Total Torque
Use Absolute PAU Torque
Use Torque 1 Input
Use Torque 2 Input
Use Torque 3 Input
Save To DAC Exit

FIGURE 12 - DYNO PARAMETERS



2.3 Diagnostic Display of System Data

The channel editor, accessible from the 'Utilities' menu as well as a display control's context menu, is used to view and edit the properties of the system data channels. Depending upon the application and configuration of the test stand, a standard set of pre-defined system data channels is will be available from the dropdown list after installation. When the utility is accessed from the context menu of a display control, it will be pre-loaded with the channel information for the channel that was associated with that display control, but the dropdown box can be used to change the current channel. An operator can further add and define new calibrated, calculated, or timed system data channels using the "Add New Channel" dropdown menu.

General Properties – This tab allows the operator to change a system data channel's name (operator-defined channels only), description, and units. In addition, channel alarm status, current raw and filtered values, and peak raw and filtered values are shown. For timer channels, the reset function can be accessed by clicking 'Reset Timer'.

Diagnostic Displa	iy of System Data				
1st Rng Pr	ess (PSI)			~	Add New Channel
General Properties	Limits and Colors	Filtering Parameters	Recording Options	Calibration Parameters	Equation Editor
	Channel Nam	e	1st Rng Press		Alarm
	Channel Desc	ription	1st Range Clu	tch Pressure	
	Channel Units	3	PSI		Reset Timer
	Channel Type	•	Calibrated		
	Time Last Up	dated	80.87		
1	Raw Value	0.0	Filtered Value	0.0	
	Peak Values				
	Raw Min	0.0	Filtered Min	0.0	
	Raw Max	0.0	Filtered Max	0.0	
			Ex	it	

FIGURE 13 - GENERAL PROPERTIES

Limits and Colors – Use this tab to define the way a system data channel looks when associated with a display control, including limits, colors, alarms, and increment. Exclude a danger or warning limit by setting the value outside the bounds of the minimum and maximum values. For each danger and warning limit, select the color for that region on a gauge, and select whether an alarm will be triggered if the channel's value is greater than a high limit or less than a low limit.

Diagnostic Display of System Data				
1st Rng Press (PSI)		~		Add New Channel
General Properties Limits and Colors Filtering Parameters	Recording Options	Calibration Parameters	Equation Editor	
Display Format	0.0			
Maximum Value	200.0			
Danger High Limit	150.0	Color	Set	s Alarm
Warning High Limit	100.0	Color	Set	s Alarm
Normal Range	0.0 - 100.0	Color		
Warning Low Limit	-9999.0	Color	Ser	s Alarm
Danger Low Limit	-9999.0	Color	Set	s Alarm
Minimum Value	0.0			
Interval	25			
	Ex	it		

FIGURE 14 - LIMITS AND COLORS



Filtering Parameters – Specify filtering parameters including old weight fraction (OWF) for a channel using infinite filtering (IIR), or a buffer size for a channel using finite (FIR) filtering. Channel filtering can smooth noisy data.

1st Rng Pr	ess (PSI)			~	Add	New Channel
General Properties	Limits and Colors	Filtering Parameters	Recording Options	Calibration Parameters	Equation Editor	
	® Use IIF ○ Use FI ○ Use N	R Filtering R Filtering o Filtering	Old We Buffer \$	ight Fraction Size	80	
			Ex	it		

FIGURE 15 - FILTERING PARAMETERS

Recording Options – Select to include this channel in datasets by selecting the "Record" option, then, select the value version to record and the data recording rate (specifying "Synchronous" will record the channel every time the value is updated, at the cost of system performance).

Diagnostic Displa	y of System Data					
1st Rng Pr	ess (PSI)			~	A	dd New Channel
General Properties	Limits and Colors	Filtering Parameters	Recording Options	Calibration Parameters	Equation Editor	
	Value Ver Update R	Ri rsion To Reco late (Hz)	ecord rd F 2	riltered ∽ 0 □	Synchrono	JS
			Ex	it		

FIGURE 16 - RECORDING OPTIONS



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Calibration Parameters – For calibrated channels only, allows the operator to view/edit various calibration parameters including source channel and number of calibration points. Calibration values can be manually entered by selecting the calibration point (turning it green), entering in the new value on the keypad, and pressing "Enter". Calibration points can also be recorded using the "Calibrate Point" button while the desired calibration point is selected. To the right, the channel's calibration is represented visually on a graph to allow the operator to check for linearity errors.



FIGURE 17 - CALIBRATION PARAMETERS

Equation Editor – The equation editor is a utility for defining the equation that is used to calculate the value of a calculated system data channel. The value of other channels can be inserted into the equation using the dropdown box and "Insert" button. Standard mathematical, trigonometric, and exponential functions are available, as well as Boolean greater-than (>) and less-than (<).

)iagnostic Displa	y of System Da	ita						
LVDT Avg	(Inches)				~		Add New (Channel
General Properties	Limits and Col	lors Filtering Parz	ameters Recordin	ng Options Calibra	tion Parameters	Equation Editor		
E	quation	(CH049+CI	H050)/2					
		sin	asin			~	Ins	ert
		COS	acos		+	• 7	8	9
		tan	atan	rand		4	5	6
		pow	exp	round	() 1	2	3
		sgrt	log	abs	<	, —	0	
				Exit				

FIGURE 18 - EQUATION EDITOR



2.4 The Display Panel

The display panel is operator-defined dashboard area for displaying the values of the system data channels using an assortment of graphical controls, including angular and linear gauges, strip charts, digital displays and indicators, etc. A new display panel control is added to the display panel by choosing a control type from the "Add New Control" submenu. Once added to the display panel, the control can then be manipulated using the mouse. Left-clicking and dragging the mouse on the control causes the control's position to change, while right-clicking and dragging the mouse on the control allows the operator to change the control's size. Once defined and customized to an operator's liking, the display panel layout can be saved to disk and recalled at any time. The buttons across the top of the display panel allow multiple display panel configurations to be switched between quickly. Display panel configurations can be associated with the five buttons in 'System Settings'.



FIGURE 19 - DISPLAY PANEL

Add New Control – Displays a menu that allows a new graphical control to be added to the display panel.

Clear All Controls – Clears the display panel of all controls.

Save Display Panel Configuration – Allows the operator to save the current display panel to disk, for recall at a later time.

Load Display Panel Configuration – Allows a saved display panel configuration to be recalled from disk.

Set Background Color – Allows the selection of the dashboard color behind the controls.

Grid – Displays the grid submenu, which allows the operator to enable/disable and configure the grid, which can be underlain on the panel to help place and size the controls.

Right-clicking on any display panel control will bring up the context menu for that control. The display panel control context menu allows for the further personalization of the display panel control, including setting its association with a system data channel. The options available in the context menu will differ depending upon the control type and the type of



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channel associated with that control, but all contain a number of functions common to all display panel control types, including Duplicate, Delete, and Reset Min/Max.

Display Control Properties – Clicking on this menu item will bring up a dialog box that allows the display panel control to be associated with a system data channel. In addition the value version of the associated channel can be chosen, as well as the control's update rate. Checking 'Synch Updates With Channel' causes the display control to be updated every time the associated channel's value is updated.

Display Control Properties			
Associated Channel	Value Version	Synch Updates With Channel	Update Rate (Hz)
2nd Rng Press (PSI)	Raw ~		20 🔹
Done			

FIGURE 20 - DISPLAY CONTROL PROPERTIES

Channel Properties – Brings up the Diagnostic Display of System Data, with the control's associated channel loaded. For more information, see the section titled 'Diagnostic Display of System Data'.

Delete – Removed the display control from the display panel.

Bring To Front/Send To Back – Allows display controls that overlay each other to move forward/back.

Reset Min/Max – Resets the stored minimum and maximum values of the system channel that is currently associated with the display panel control.

Duplicate – Creates an exact copy of the display control, including the associated channel, size, and all display control-specific settings, and adds it to the display panel at the default position.

The following context menu options are available only for the strip chart display control type:

Pause/Unpause Graph – Stops/starts the accumulation of new data points on a strip chart.

Set Buffer Length – Set the amount of time, in seconds, to show in the history of the strip chart.

Set X-Axis Interval – Set the amount of time, in seconds, between the vertical grid lines of the strip chart.

The following context menu options are available only for the numeric LED display control type:

Set Number Of Digits – Set the number of digits displayed on the numeric LED.

Set Segment Width/Separation/On Color/Off Color – Further customize the look and feel of the numeric LED display control.

The following context menu options are available only for the light strip display control type:

Set Orientation – Change the orientation of the light strip to vertical or horizontal. Set Segment Number Of Divisions/Separation/Segment Color – Further customize the look and feel of the light strip display control.

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Other display control types allow for further graphical customization using control-specific context menu items. The text-based display controls value label and constant label allow the setting of the font size, background color, text, etc. Any display control that is associated with a timer channel also has a 'Reset Timer' menu item available in its context menu (timer channels can also be reset in the general channel properties).

Dataset Viewer - The Dataset viewer is a utility used for viewing and analyzing recorded test data. The datasets loaded to the viewer are created during a manual (constant target) test or a scripted test, and contain the data for all of the channels recorded during the duration of the data recording session. While the viewer is capable of showing any number of channels in the graph area at once, it can show only two y-axes at a time, one on either side of the graph.



FIGURE 21 - DATASET VIEWER

The following mouse gestures are in the graph area:

Left mouse button drag – Draws a box around an area to be zoomed. Right mouse button drag – Pans the entire graph. Mouse wheel up/down – Zoom in/out on the entire graph. Mouse wheel click – Draw a cursor on the screen.

Clicking 'Legend' will display a table of all recorded channels. Check the box in the 'Visible' column to make the channel visible in the graph area. Scroll the mouse wheel up/down with a channel selected in the legend to zoom in/out on just that selected channel. Right-click on an individual channel's name in the legend to show a context menu for that channel.

Select Color – Change the display color of the channel on the graph.

Set Y-Axis Left/Right – Show the channel's Y-axis on the left/right side of the graph.

Set Minimum/Maximum Value – Type in the minimum or maximum value of the channel's y-axis.

Set To Full Scale – Set the channel's y-axis values to encompass the full scale of the channel over the duration of the dataset recording session.

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The following options are available in the dataset viewer's menu, accessible by clicking on the button labelled 'Menu':

Force All Channels Full Scales – Forces the y-axes of all channels in the dataset to encompass the full scale of the channel over the duration of the dataset recording session.

Force All Channels Same Scales – Enter the minimum and maximum values, to be applied to the y-axes of all of the channels in the dataset.

Force X-Axis Full Scale – Set the x-axis to display the entire duration of the dataset.

Set X-Axis Minimum/Maximum – Set the beginning and end time to show on the graph.

Line/Scatter Graph – Select to connect the points of the dataset with a line or show the points only.

Thin/Thick Lines – Decrease/increase the width of the plot lines on the graph.

Change Background Color – Set the background color of the graph and scale areas.

Change Grid Color – Set the color of the grid underlay in the graph area.

Change X-Axis Color – Set the color of the x-axis (time) scale font.





Certificate of Registration

Mustang Dynamometer

2300 Pinnacle Parkway, Twinsburg, OH 44087, USA

have been assessed and approved to:

ISO 9001:2015 Quality Management System

The approved management system applies to the following scope:

Provides the design, manufacture and supply of dynamometers and industrial testing equipment and systems.

Original Approval: Current Certificate: Certificate Expiry: Certificate Number: 18th August 2003 16th July 2024 16th July 2025 US1950

Signed: Certification Officer

MBoyan

This certificate remains valid while the holder maintains their administration systems in accordance with the standards and guidelines stated above, which will be audited annually by QAS International. The holder is entitled to display the above registration mark for the duration of this certificate, which should be returned to QAS International upon reasonable request

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FIGURE 22 - ISO 9001:2015 CERTIFICATION CONFIDENTIAL

Page 19 of 19