technicalNOTE

How to Create an Efficient Structural Testing System

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INTRODUCTION

Passing the structural test is one of the most critical tasks in the entire design process of large-scale structures such as aircraft, satellites, wind turbine blades, landing gear, and more. Engineers are required to conduct different tests to study the behavior of the structure under different stressors to determine its strength, compare the acquired data with expected results, and ensure the structure under test can tolerate an expected amount of strain/pressure without failing.

Completing structural tests is often expensive. They require a lot of man power, resources, and time, as they are very complex to conduct. There are many kinds of structural tests, some of which are one-time tests and some of which are required to run for years and so the test system and the acquired data has to be very accurate, reliable and repeatable.

Tight project schedules also mean that there is no room for errors and that the test system in use must save time and money while still providing the best results. Use of the intuitive DAQ software can make setting up and completing structural test simple and quick, while providing in-depth data and capabilities.

In this paper we will discuss how EXLab, a full-feature data acquisition software suite, and the EX1629, a precision strain instrument, can work together to become a complete structural test suite and help engineers save time and money on tests.

ALL-IN-ONE VS. MODULAR

As structural testing can be complex and time consuming, engineers must be aware not to exhaust resources and time on configuring their own data acquisition system, and focus solely on completing the structural test.

If engineers are required to configuring their own DAQ system for use in the structural test, they must conduct research for selecting the proper components such as system chassis, signal conditioning modules, data acquisition modules, terminal blocks and wires.

VTI Instruments

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Once the system is successfully configured, there will be significant time spent on building and verifying cables using within the system. Extra cabling can often add substantial costs, make maintenance of the system complicated, and also reduce the data integrity due to noise and interference.

The EX1629 is an all-in-one strain instrument with embedded signal conditioning and data acquisition capabilities. No external modules and wiring are required, allowing for easy setup and maintenance, with high signal integrity. The end-to-end self-calibration, shunt calibration, and excitation measurement ensure superior accuracy.

TURN-KEY SOFTWARE SOLUTION VS. PROGRAMMING

There are benefits to both turn-key software solutions and to custom software applications. In order to create a custom software application, engineers are required to purchase a software license which can be expensive.

Creating custom software also involves several time consuming tasks associated with it. These tasks include:

- Understanding the suppliers software driver
- Developing a software application to control the hardware
- Verify and debug the software application

A turn-key software solution, however, can deliver a complete structural test software suite which does not require any programming. This allows engineers to begin testing immediately with no time wasted on development.

EASY CONFIGURATION ON INDEPENDENT CHANNELS

A large-scale structural test requires hundreds or thousands of channels to acquire data. Connecting the different strain gages to the channels of the DAQ system and setting up all the channels in the software can be tedious, time consuming, and prone to human error.

EXLab provides an easy-to-use channel configuration mechanism that allows the user to setup all channels efficiently.

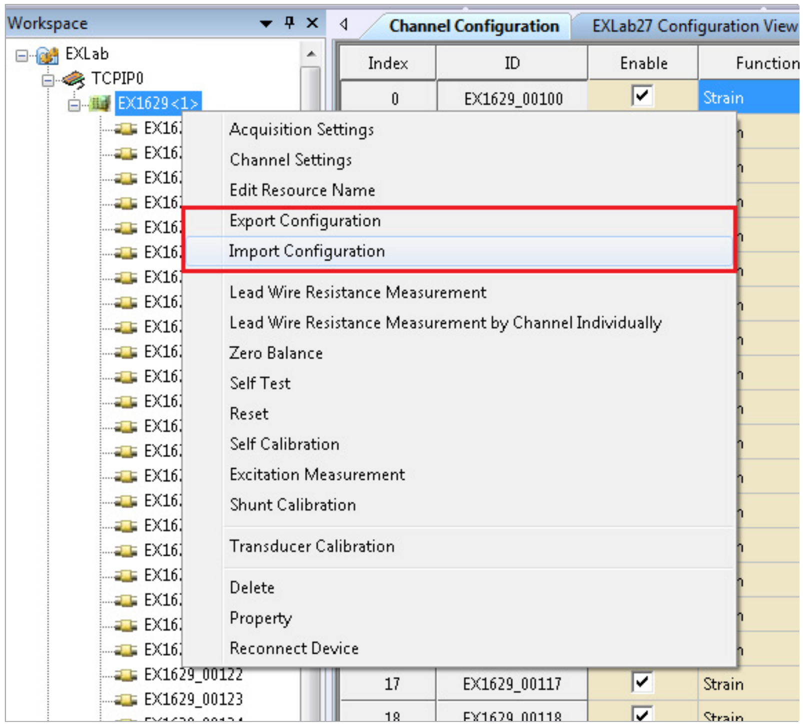


FIGURE 1: CHANNEL CONFIGURATION IMPORT AND EXPORT

EXLab's ability to simulate virtual instruments also means that channel setup can be done without connecting the instrument. This means that some engineers can be working on attaching sensors and completing wiring, while others can configure channels with the simulated instruments. When the instruments are ready to use, the engineers just need to apply the pre-configured channel configurations to the instruments. In this way, the engineers work in parallel and drastically reduce system setup time.

Each channel of the EX1629 has an independent ADC and can be set to independent range, measurement type, bridge type, completion resistance, filters, etc. By using the EX1629 with EXLab, engineers are not limited by any restrictions and can complete the entire channel setup process within software.

FIGURE 2: EX1629 FRONT VIEW WITH 48 INDEPENDENT CHANNELS

DISTRIBUTION DATA MONITORING ON DISTRIBUTED INSTRUMENT

In large-scale structural testing, it is common to require hundreds or thousands of strain gages to be placed in different locations throughout the structure. Since there needs to be many channels, it is difficult for engineers to distinguish the location of each strain gage.

EXLab provides a Distribution Graph, allowing engineers to first assign a custom name to each channel of the data acquisition system and assign the channel into a distribution graph.

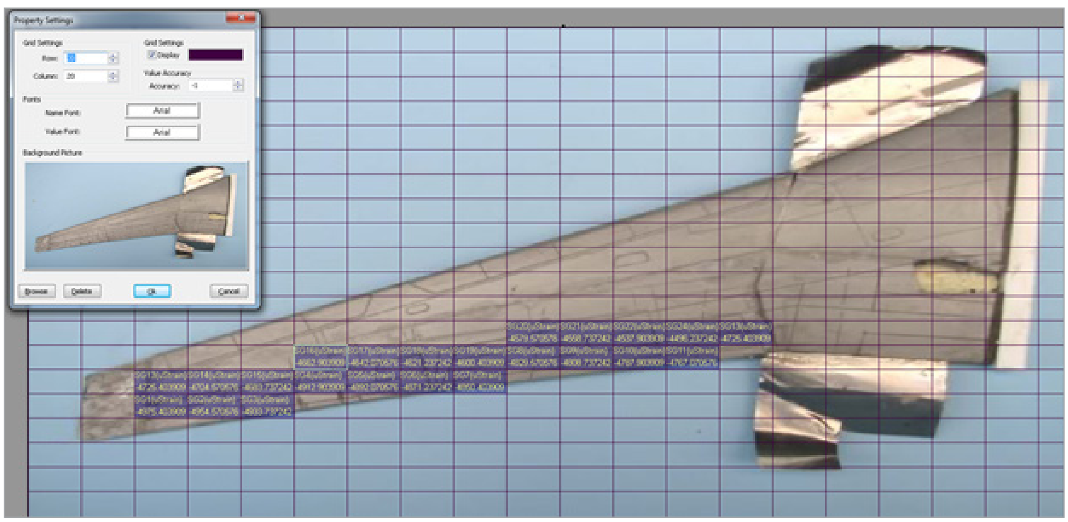


FIGURE 3: DISTRIBUTION GRAPH WITH DATA ASSIGNED ON DIFFERENT LOCATIONS OF A PICTURE OF A AIRPLANE WING

The distribution graph allows the user to upload the picture of the structure under test into EXLab, specify how many rows and columns are used in the picture and assign the channels into cells. By using the distribution graph, engineers can easily distinguish the location of the channels as well as the strain gages. When a channel fails, the engineer can know exactly where the failed strain gages locate and fix them without spending any time to find out the locations.

Since structures under test are usually very large, multiple distribution graphs might be required. EXLab supports multiple distribution graphs, each of which monitors a part of the structure under test, while running at the same time. However, to achieve this, it is required to run long test cables to connect the instruments to different parts of the body of the structure.

Running long test cables can significantly reduce the data integrity as well as the accuracy. EX1629 is an LXI instrument which uses LAN for communication. The instrument can be easily distributed and placed in different parts of the body of the structure with only one LAN cable. In this way, no long test cables are required and data integrity and accuracy can be ensured.

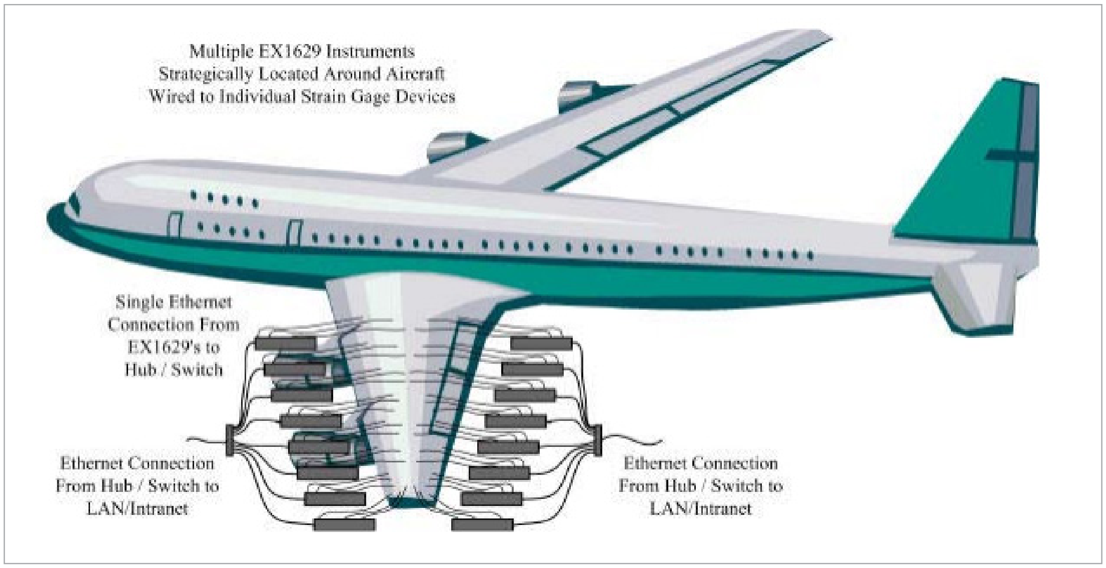
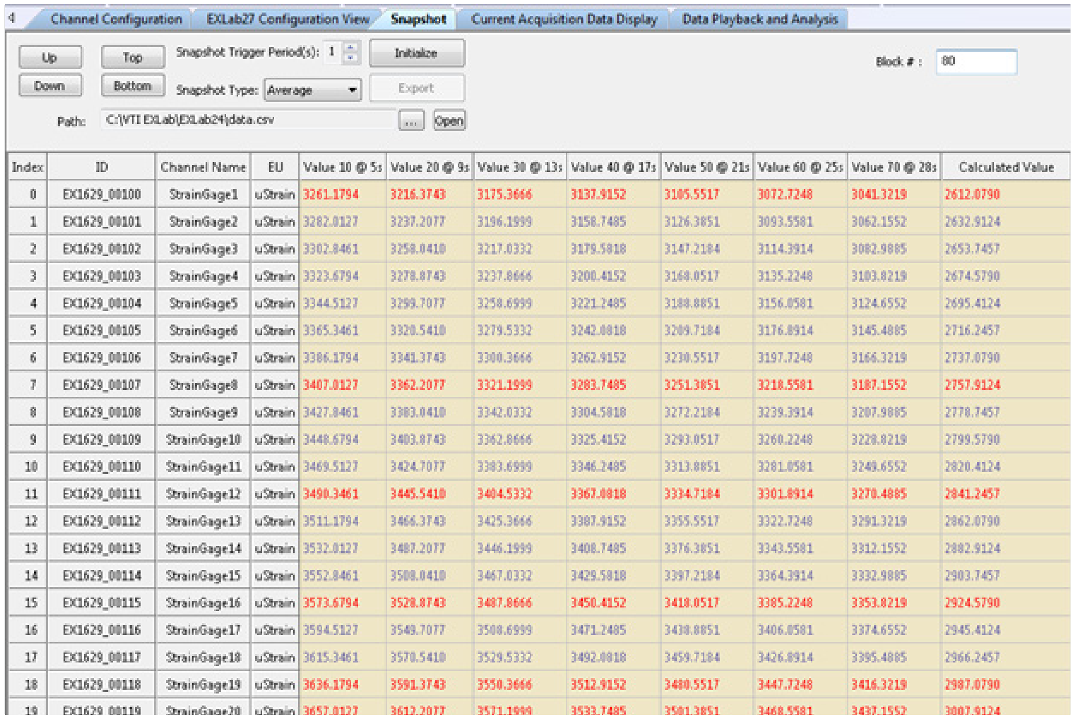


FIGURE 4: DISTRIBUTED EX1629 IMPLEMENTATION CONCEPT

MANUAL SNAPSHOT & AUTO SNAPSHOT

In static load tests, engineers have to continuously operate a load control system to apply force to the structure under test in different levels and determine the structural behavior of the structure by analyzing acquired data. The engineers can manually set the load control system to apply certain levels of force to the structure under test and manually acquire data using the Snapshot feature of EXLab. EXLab allows the user to visualize the data from all channels along with the information of the load control system in a table format.

Each channel is assigned a channel name and can be moved up or down in the table, allowing the engineer to focus on important channels. The data will also turn into red whenever it exceeds the preset limit. This creates a warning for the engineer and clearly displays the failure position, the failed value, the time of the failure and the amount of force applied on the structure when it failed.



Index	ID	Channel Name	EU	Value 10 @ 5s	Value 20 @ 9s	Value 30 @ 13s	Value 40 @ 17s	Value 50 @ 21s	Value 60 @ 25s	Value 70 @ 28s	Calculated Value
0	EX1629_00100	StrainGage1	uStrain	3261.1794	3216.3743	3175.3666	3137.9152	3105.5517	3072.7248	3041.3219	2612.0790
1	EX1629_00101	StrainGage2	uStrain	3282.0127	3237.2077	3196.1999	3158.7485	3126.3851	3093.5581	3062.1552	2632.9124
2	EX1629_00102	StrainGage3	uStrain	3302.8461	3258.0410	3217.0332	3179.5818	3147.2184	3114.3914	3082.9885	2653.7457
3	EX1629_00103	StrainGage4	uStrain	3323.6794	3278.8743	3237.8666	3200.4152	3168.0517	3135.2248	3103.8219	2674.5790
4	EX1629_00104	StrainGage5	uStrain	3344.5127	3299.7077	3258.6999	3221.2485	3188.8851	3156.0581	3124.6552	2695.4124
5	EX1629_00105	StrainGage6	uStrain	3365.3461	3320.5410	3279.5332	3242.0818	3209.7184	3176.8914	3145.4885	2716.2457
6	EX1629_00106	StrainGage7	uStrain	3386.1794	3341.3743	3300.3666	3262.9152	3230.5517	3197.7248	3166.3219	2737.0790
7	EX1629_00107	StrainGage8	uStrain	3407.0127	3362.2077	3321.1999	3283.7485	3251.3851	3218.5581	3187.1552	2757.9124
8	EX1629_00108	StrainGage9	uStrain	3427.8461	3383.0410	3342.0332	3304.5818	3272.2184	3239.3914	3207.9885	2778.7457
9	EX1629_00109	StrainGage10	uStrain	3448.6794	3403.8743	3362.8666	3325.4152	3293.0517	3260.2248	3228.8219	2799.5790
10	EX1629_00110	StrainGage11	uStrain	3469.5127	3424.7077	3383.6999	3346.2485	3313.8851	3281.0581	3249.6552	2820.4124
11	EX1629_00111	StrainGage12	uStrain	3490.3461	3445.5410	3404.5332	3367.0818	3334.7184	3301.8914	3270.4885	2841.2457
12	EX1629_00112	StrainGage13	uStrain	3511.1794	3466.3743	3425.3666	3387.9152	3355.5517	3322.7248	3291.3219	2862.0790
13	EX1629_00113	StrainGage14	uStrain	3532.0127	3487.2077	3446.1999	3408.7485	3376.3851	3343.5581	3312.1552	2882.9124
14	EX1629_00114	StrainGage15	uStrain	3552.8461	3508.0410	3467.0332	3429.5818	3397.2184	3364.3914	3332.9885	2903.7457
15	EX1629_00115	StrainGage16	uStrain	3573.6794	3528.8743	3487.8666	3450.4152	3418.0517	3385.2248	3353.8219	2924.5790
16	EX1629_00116	StrainGage17	uStrain	3594.5127	3549.7077	3508.6999	3471.2485	3438.8851	3406.0581	3374.6552	2945.4124
17	EX1629_00117	StrainGage18	uStrain	3615.3461	3570.5410	3529.5332	3492.0818	3459.7184	3426.8914	3395.4885	2966.2457
18	EX1629_00118	StrainGage19	uStrain	3636.1794	3591.3743	3550.3666	3512.9152	3480.5517	3447.7248	3416.3219	2987.0790
19	EX1629_00119	StrainGage20	uStrain	3657.0127	3612.2077	3571.1999	3533.7485	3501.3851	3468.5581	3437.1552	3007.9124

FIGURE 5: SNAPSHOT

A static load test can be a very expensive one-time test. Once the structure breaks, the test cannot be continued and rebuilding the structure can be expensive. With this warning in Snapshot, the engineer can stop the test before the structure breaks apart when warnings appear.

Combining Snapshot with the Event Management feature, EXLab can create a closed-loop, automated static load test. To achieve this, the user can setup a system event and an input event in EXLab. System event is used to send out a trigger signal from the data acquisition hardware to trigger the load control system and advance to the next level once the snapshot measurement is finished. The input event is used to detect trigger signals from the load control system and trigger the data acquisition system to snapshot the data. The whole operation will become a closed-loop control and data can be acquired automatically.

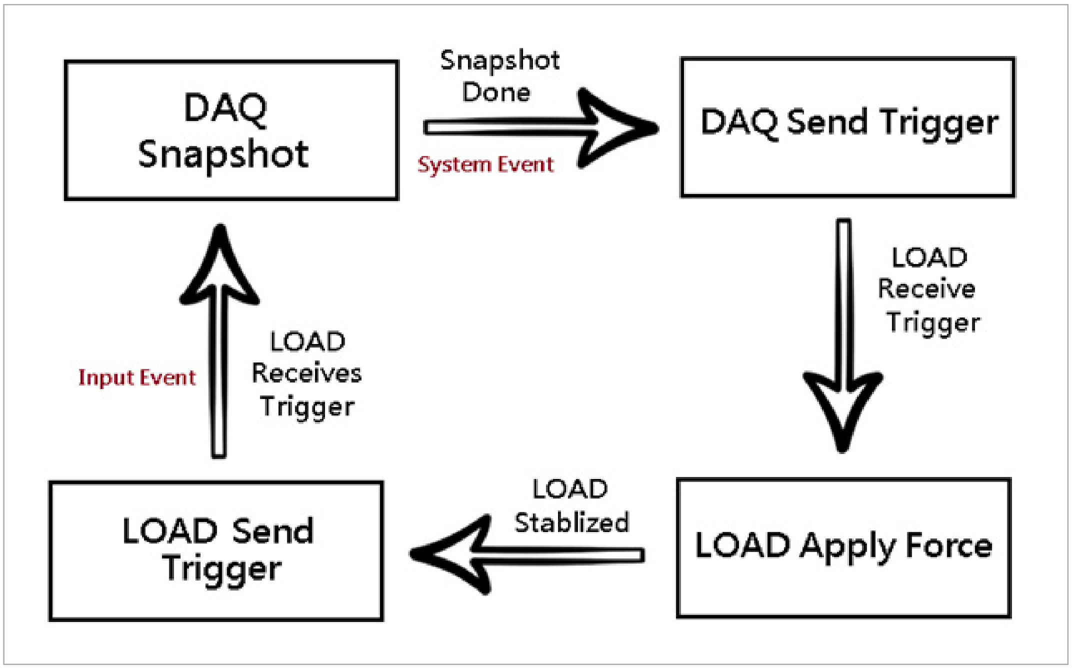


FIGURE 6: CLOSE-LOOP CONTROL CONCEPT DIAGRAM

LOOP RECORDING

Fatigue testing can often be required to run for months or even years in order to achieve complete test results. Even though the data sampling rate is not high, the size of data recorded in months or years can be huge. Not only it will require more computer memory to store the data, but much of the data will also become redundant and meaningless, causing it to be very difficult for the user to navigate useful data.

EXLab can resolve this issue by using loop recording. Loop recording allows the user to specify the total amount of data files and the time of each data file used to store data. In this mechanism, new data will always replace the old data in order to keep the specific amount of data specified by the user.

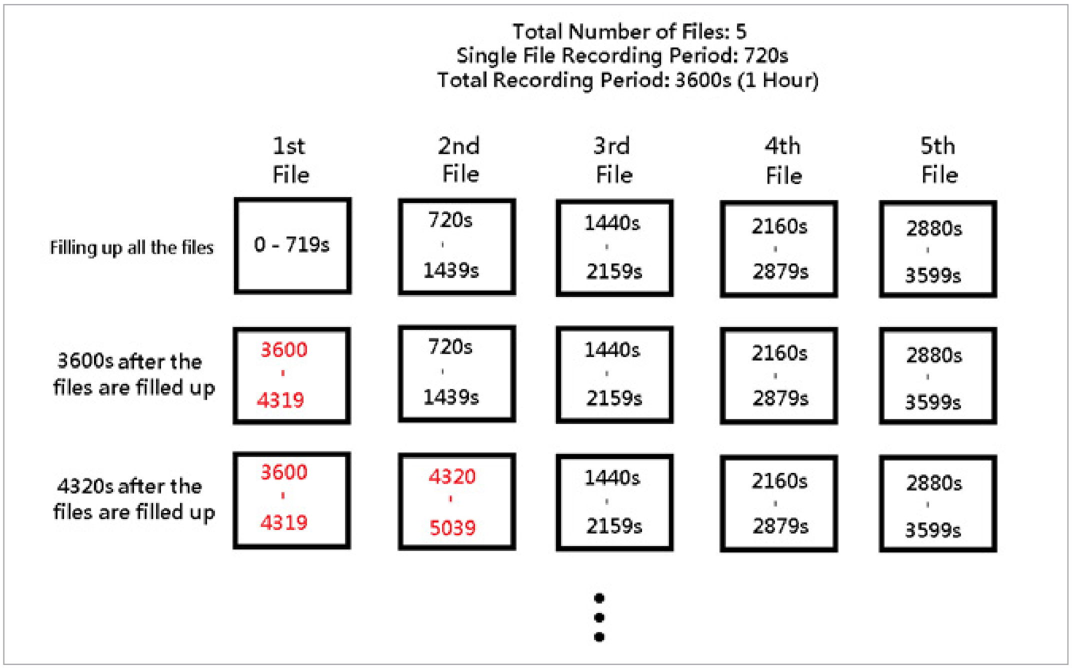


FIGURE 7: LOOP RECORDING CONCEPT DIAGRAM

By using loop recording, engineers are no longer required to manage months or years of data. Combing with Event Management, the engineer can setup an output event to send out a trigger signal to shut down the whole system in case of emergency. Then the engineer can analyze the acquired data recorded within only a specified amount of time.

CUSTOM ALGORITHMS

In structural test, calculating a value using different algorithms based on acquired physical data is common (Strain Rosette for example). Algorithms can be complicated and can be automated using software. EXLab provides a capability to allow users to customize their own algorithms or formulas. Based on the data from one or more channels, a desired value can be automatically calculated in real time and store into virtual channels. Virtual channels can be used in the same way as physical channels. In other words, the calculated value can be displayed on a data display control, exported into CSV format file or analyzed using post-data analysis tools. Users are also allowed to apply different rate to calculate the value.

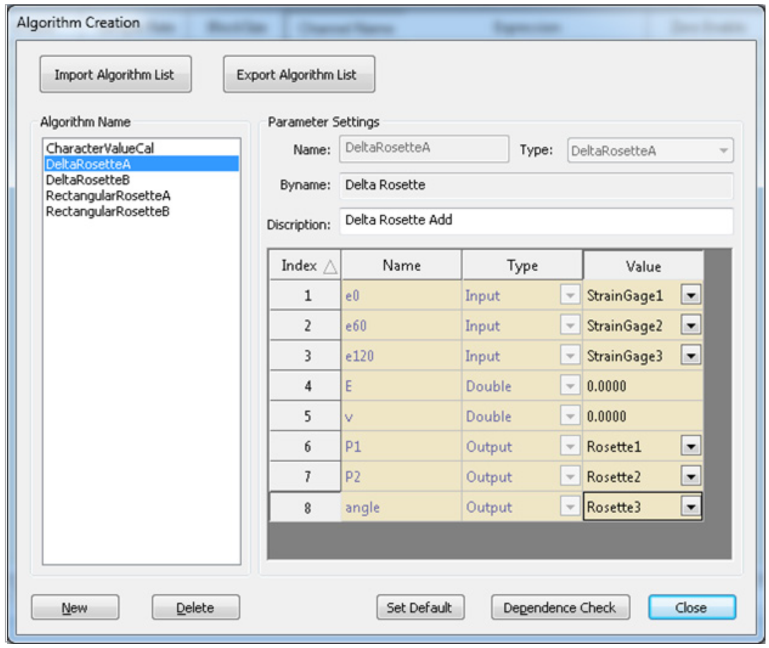


FIGURE 8: DELTA ROSETTE IN CUSTOM ALGORITHM

In large-scale structural tests, intensive calculations can happen simultaneously. By using EXLab, algorithms and formulas can be setup prior to the test. During the test, the results will be directly reported. Engineers are no longer required to do post-data analysis based on the acquired data from the physical channels. Not only does this save time but is also more organized.

MAXIMIZE ACCURACY

The EX1629 supports many various functions to maximize the accuracy of the measurement, including; self-calibration, shunt calibration and excitation measurement. These functions can dramatically reduce data uncertainties in different circumstances. EXLab supports all of these functions. Each function can be performed by one click and the results will be shown once the process of the function is finished. These functions also allow the user to do quick validation on the data acquisition system to detect failures.