Embedded, Real-Time Acquisition and Control System for Functional Validation of Automotive Spring Evaluation System

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Abstract: The Automotive Spring Evaluation test is done to acquire the Real-time data for the functional verification of Spring systems of the car. The module which is going to be built will be of universal type. Universal will mean that, the different type of Spring Evaluation systems of different car companies can be tested using a single machine. Basically, in this project the Device Under Test is the Automotive Spring systems. Automotive Spring system is the Electro-Mechanical part, there will be two potentiometers built inside the ASES (Automotive Spring Evaluation System). The signal is obtained based on the force applied. Two potentiometer is connected to test the synchronous values of the signal obtained. The Real-time data obtained due to the force applied on the spring system is sampled in terms of milliseconds, to obtain the better data reading ability. The test machine is built such that it can be controlled via PC.

Keywords: Automotive Spring Evaluation System(ASES), Force applied, Synchronous values, Lab VIEW programming.

Introduction

The Automotive Spring Systems are one of the important parts of the Automobiles. These modules are tested for their Endurance and Functionality. A work bench is built, to check both Endurance and Functionality. The ASES from different vendors can be fit to the work bench to test the Functionality and Endurance. The work benches were built previously also from different companies, but, there were drawback in terms of the software used, the hang of the code due to continuous running of the work bench. The present work bench built uses the NI products, including the Lab VIEW software. The code is developed using the Lab VIEW software. The standard used to build the code is an advanced method. The software will be run as an application to test and obtain the values from the ASES.

The OS of the PXI is coded with the RT programming. Hence RT program bridges the communication between the command from PC to the hardware and vice versa. The complete working and the data acquisition is explained in further section. The results obtained and discussion can be seen in section VI.

The Workbench Setup

There are three different stands for different connections and mounting. The first stand is used to specifically mount the ASES’s. The ASES consists of two potentiometers, which give out the output voltage of the spring system, which is directly proportional to the force applied on the spring systems. The maximum number of ASES’s connected is 8. The loadcells are connected to realize the amount of load [3] applied on the spring systems. This ASES stand is placed next to the stand on which the servo motor is mounted.

In the servo motor stand, also has the step-down transformer. The main power supply, 420V, which is the Industry standard voltage, is stepped down to 240V. Further, the 240V is connected to isolators and relays to supply different voltages to different hardware components. The 240V supply is given to the DC servo motor [5]. Based on the speed set by the Test engineer the motor is run correspondingly and thus the speed of the ASES is maintained [1]. To the servo motor, encoder is connected. The code built on PC can control the movement of the servo motor.

The working of the code will be explained in the next section. The third stand used, consists of SCB’s (Shielded I/O Connector Blocks), the PXI, the modules for the PXI, Isolators, Relays, Connectors, PC connected to the PXI. The isolators are used to control the current through different devices. The relays are used for safety purpose. SCB’s are the connector plates, which connect from PXI modules to isolators, relays.

Working of The Sensors and Encoder

The modules usage differs based on the sensors used. In this project, the sensors used are the loadcells, the two inbuilt potentiometers in the ASES. The output from these two sensors are analog voltage. The number of cycles to be performed by the ASES are given on the application software, and it is communicated via the PXI to the rods connected to the servo motor, which in turn applies the force to the ASES. The output voltage of the potentiometer reading and the loadcell voltage are communicated to the PC via the PXI.

The encoder [6] maximum and minimum values should be Pre-set. Once the encoder attains the maximum value, it resets back to the minimum value. Here the value of the encoder, refer to the angle.

During the functional test, the maximum and minimum values of the encoder are not set. The spring systems mounted, can move to the maximum limit to check if the wears are present. The maximum limit is detected by load sensor which will be placed below the spring system.

The Software

Lab VIEW is a graphical programming language used by engineers, scientists to control, test and analyse on a variety of operating system and is user defined.

The code in Lab VIEW is built on the VI (Virtual Instruments). The VI consists of three parts, Front Panel, Block diagram, Connector pane. The Front panel is for User Interface, the Block Diagram is for actual coding, and connector pane to make the VI as the sub VI and providing the connections for the same.

The software we design for the project should be done in such a way that it should be understood by other engineers for future enhancements. The present code developed consists of different VI's in Host and RT. The host programs are developed in PC for the user interface. The RT [2][4] programs are developed for the communication with PXI. The main host VI's developed are the Test screen, Diagnostics screen, Configuration screen. The Diagnostics screen, Fig. 1 is where the test engineer can control the work bench manually and the data from sensors are obtained. In Diagnostics screen, the speed, torque, direction of the servo motor is varied manually by pressing the buttons on the screen. The command sent from the diagnostics screen is communicated to RT [4] via the network stream, and thus the PXI communicates the commands to the hardware.

The test screen Fig. 2 is where the Spring system information like, the angle, the potentiometer output of the spring system, the synchronous behaviour of the potentiometer of the spring system are plotted.

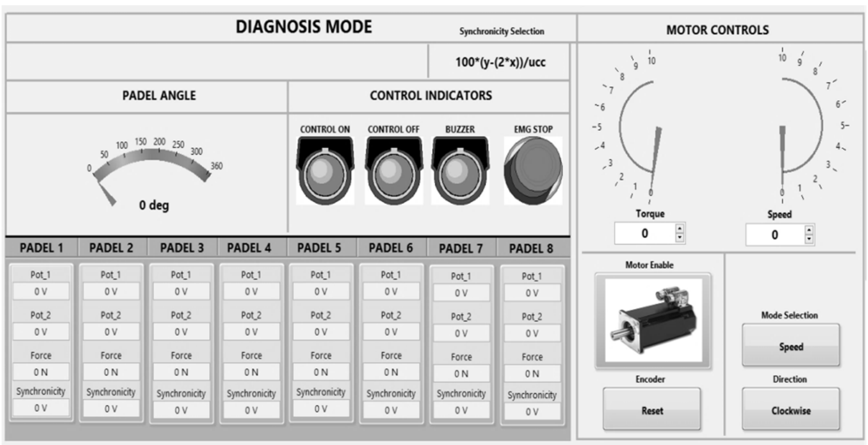

Figure 1:Diagnosis Screen

Also, the error of the output voltage is recorded and plotted. The time is set by the test engineer, for how much time interval the overall data, errors are to be stored. The graph data gets updated once the test engineers gives the start command. The graph data gets stored in the excel format at regular intervals of time, as set by the test engineer. The Configuration Screen Fig. 3 and 4 is where the values are set for the automatic mode of working. The analog values can be set by the test engineer, but none of the hardware can be controlled manually by the test engineer. The values like, the error range for different spring system modules, the errors in terms of, synchronisation of signals, the individual potentiometer error values, the spring system configuration values can be set. The errors range is sent from configuration to RT, in RT the values are segregated based on the error limit. The values of the spring system ranging out of the given range will be treated as error by the RT and those values are sent to configuration screen as the errors and are stored for regular intervals of time to monitor the errors. The values of the spring system, without filtering the errors are updated as graph on the Test screen. The functional test is done once after N number of endurance test cycles. The functional test is done to ensure the physical damage of the ASES.

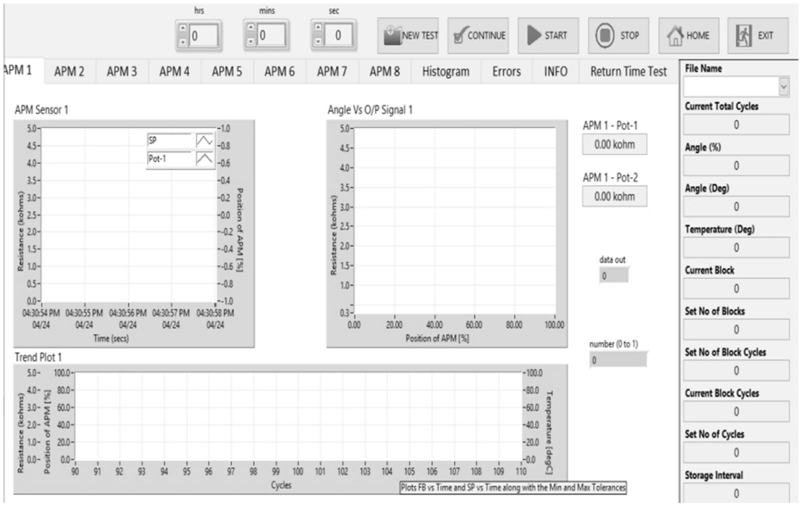

Figure 2: Test Screen

The damage in ASES will be known by studying the graph of the functional test. The endurance test gives the information of the ASES during every cycle travel of the same. Using the data values of the cycles during the endurance test and the functional test data, the pass and fail of the ASES is done. And further processing of the ASES is carried out.

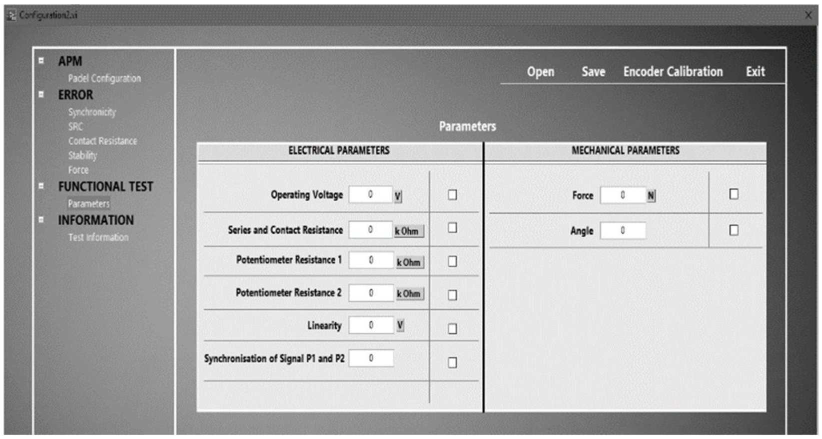

Figure 3: Configuration Screen to enable the values to be stored

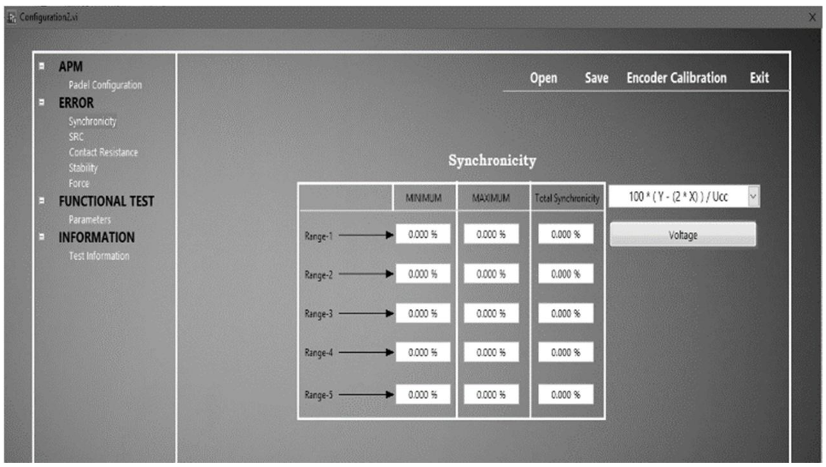

Figure 4: Configuration Screen to set Error ranges

The Overall Block Diagram

The block diagram Fig. 5 gives the detail of how exactly the software, PXI, hardware interaction takes place. The Computer(Host) is where the code for UI (User Interface) and RT. The software is communicated with the PXI using RT [4]. The command given by Test Engineer is communicated to the hardware using PXI.

Functional test and the test results are simultaneously sent on the Host screen and are recorded as the data. There are different types of converters used, these converters are used to convert the 240v supply to different values of supply to load cells and potentiometers of the ASES.

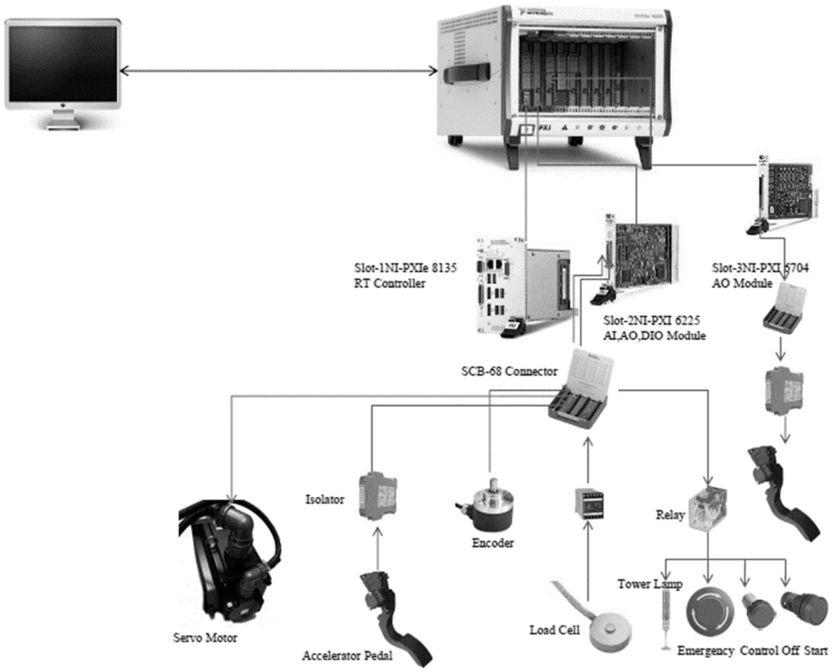

Figure 5: The Block Diagram of the Overall Project

Results and Discussion

After conduction of the Endurance test the results are plotted on the graph. Also, if the Test engineer had made selection to save the cycle error data during the configuration, then all the error data along with the raw data of the cycle for the pedals will be saved in the predefined folder for the future references. Based on the raw data and the error data, the selection of the ASES will be made. The Potentiometer outputs are seeing to be sinusoidal, because, to the Spring System the constant force is applied, for which the ASES attains the maximum and minimum position for the set number of cycles. The voltage output for one cycle can be seen in the Fig. 6. Here there is no data filtering based on the ranges set. The whole data is displayed. If the errors occur, there will be occurrence of the glitches.

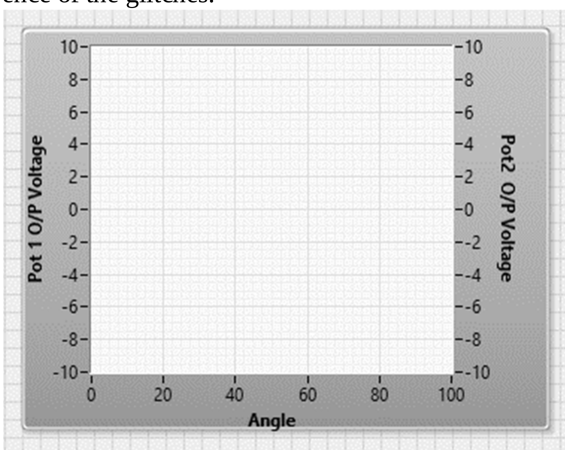

Figure 6:The Plot for the Potentiometer outputs for a Single Spring System

The Table. 1 below shows the error data, during the Endurance test. In this case, the error range set for Pot1 and Pot2 are 0.5V (minimum value) and 4.5V (maximum value). From the table which is obtained by real time testing we can incur that, the out of range values occurs most of the times in the ASES model SS4. These values are stored for the reference in the desired formats.

Table 1: The table with the error log from different ASES models

Supply Voltage	ASES Model no.	Pot 1 error values	Pot 2 error values
5V	SS4	0	0.2
5V	SS4	5	4.9
5V	SS3	0.2	0.3
5V	SS4	0.1	0
5V	SS4	5.2	5.5
5V	SS6	0.3	0.4
5V	SS4	0.1	0

Similarly, after the set number of cycles, the functional test will get performed. The functional test is performed to check other parameters like synchronicity, Force, Pot1 and Pot2 voltage, Linearity. The below figure shows the graph of the functional test results. During the Functional Test Fig. 7, the Test engineer will not set the maximum and minimum ranges. The ASES is allowed to move to the maximum by applying the force, and once the maximum limit is reached, the load cell senses it and further there will be no motion. Then the force applied will be released, once the encoder senses the maximum limit attained by the load cell. Thus, the plots for different parameters are obtained for further verification about the ASES.

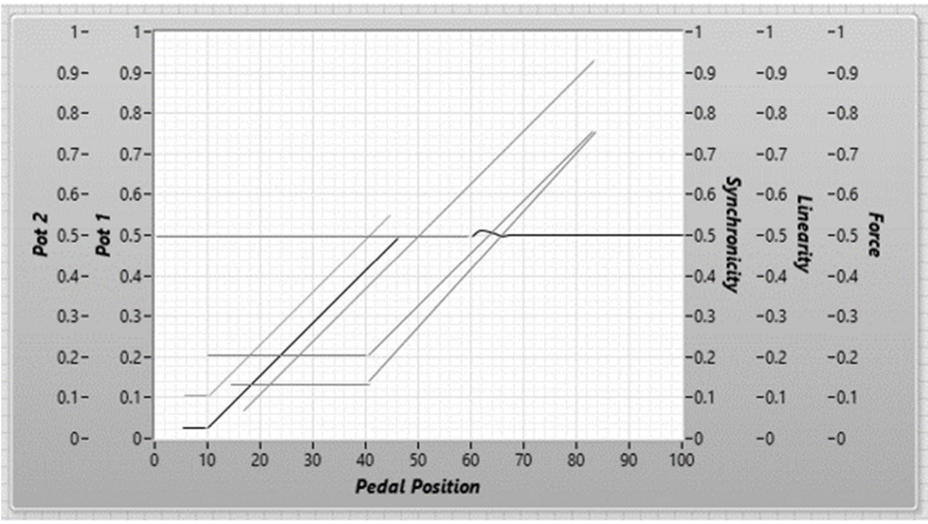

Figure 7: The graph obtained for Functional Test

Conclusion and Future Scope

This paper concentrates and describes about how the ASES endurance test and functional test is carried out. The tests can be carried out manually and automatically as well. The data acquisition can be done for both, error, and error free formats. Based on the error values the ASES vendor can take further actions on the further processing and testing of the ASES.

For the future developments of the test bench, the ASES test with respect to temperature consistency and variation can be done. The tests can be extended to APM's (Accelerator Pedal Module), Door lock system, Throttle body.

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