

# Acceptance Testing of Electro Hydraulic based Aircraft Actuator using LabVIEW

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*Received: 16 December 2013 Accepted: 31 December 2013 Published: 15 January 2014*

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## Abstract

This paper presents an approach to perform aircraft actuator Acceptance Testing capability. Efforts include design and development of Test system for Electro Hydraulic aircraft actuator, in nominal condition that may be used along with measurement data to generate effective test results. LabVIEW platform is used for developing the test system. To develop communication between the LabVIEW based Test software and Actuator, Portable Test Controller (PTC), is used.

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**Index terms**— LabVIEW, Portable Test Controller (PTC), Electro-Hydraulic (EH) and Smart Test Controller Unit (SCU).

Of the various kinds of actuators, EHAs were chosen for this study because of their growing role in the aerospace field. They are relatively compact and can offer high power-to-weight ratios and motion velocities.

[Andrew ??oldenberg & Saeid Habibi, 1999].

Actuator Acceptance Testing at Assembly and Production Floor is to determine, if the requirements of a specification or contract are met. It may involve functional tests, physical tests, or performance tests. But for EH based actuator it's a performance testing, which included Testing the aircraft actuator for its basic functionality, including sensors functionality under the hydraulic pressure and real condition environment. [H. Moon and W. Knowles, 1970] [G. McGrath, 1964].

Electrical actuation technologies have to comply with demanding aircraft requirements concerning reliability, performance, weight, and environmental conditions. Electro Hydraulic actuation use comes from customer and airworthiness requirements for clean and more environment friendly aircraft.

The use of Electro Hydraulic actuators helps in aircraft maintenance. Airlines across the globe are looking for more efficient aircraft that can increase their net profit. The increasing fuel price is a major driving factor, forcing the aircraft manufactures to opt for more fuel efficient actuation systems.

With the primary functions in the aircraft more powered by electrical and hydraulic system; rather than conventional Pneumatic system aircraft will be able to achieve reduced fuel burn, higher reliability, reduction in maintenance cost, and more dispatch availability. Many R&D programs are going on in this industry for saving fuel and enhancing operational efficiency.

The instrumentation requirements in the area of automotive testing has increased many folds owing to the increasing and stringent demands imposed by several regulatory bodies such as the BIS, CMVR, EEC, etc. The type of tests to be carried out depends upon the purpose of evaluation such as for certification, design validation, etc. The parameters to be evaluated pertaining to the testing of vehicles are many. Presently, a number of dedicated instruments are being employed for the above purpose, each instrument meant to carry out evaluation of a specific parameter. However, one of the major disadvantages in such instruments is that their functionality is rigid and is difficult for reconfiguration. It I.

## 1 INTRODUCTION

eing relatively new to the aerospace industry, Electro Hydraulic actuators are being used widely in aircraft. The quantum of knowledge as compared to ones accumulated for the other actuator types are much less and

45 especially when it comes to Acceptance Testing. Lack of health monitoring data from the system installed in field  
46 and prohibitive costs of carrying out real flight tests push for the need of building system models and designing  
47 affordable but realistic experimental setups.

48 An electro-hydraulic system comprising an electromagnetic actuator and a hydraulic actuator relatively  
49 arranged such that the movement of the hydraulic actuator is controlled by the movement of the electromagnetic  
50 actuator.

51 The electromagnetic actuator is preferably a linear motor with a piston rod arranged to reciprocate in  
52 response to electric signal supplied to the electromagnetic actuator. A pump is preferably arranged between  
53 the electromagnetic actuator and the hydraulic actuator and causes movement of the hydraulic actuator as a  
54 result of the movement of the shaft of the linear motor. [J. ??dge, 1978] [G. Daneker, 1973].

55 Electro-Hydraulic Actuators (EHA) are presently used in numerous aerospace applications, from robotic  
56 applications to thrust vector control of rocket engines, where they accomplish a range of rotational and  
57 translational functions ].

## 58 2 B Year 2014

59 requires the adjustments of many hardware components to achieve the desired functional behavior. It was,  
60 therefore intended to have an instrumentation system, which could be completely customized to the users  
61 requirements and at the same time be flexible enough to cater for the changing requirements of the test  
62 methodologies pertaining to the variation in the test standards.[S V Londhe et al, 1999]In view of this Moog Inc  
63 has developed test controller hardware for testing and validating the EH actuators.

64 A detailed description has been provided about the architecture of acceptance systems and how various cases  
65 for acceptance are tested in the test environment and corresponding data is collected to verify the physics based  
66 models.

67 A design and development of test system has been included to outline the details of experimental data collection  
68 and calculate the results depending upon the collected data and predetermined data. Furthermore, some idea  
69 about how actuator performs in real flight environments through actual flight tests and using real flight data  
70 have been presented. Finally, the roadmap leading from this effort towards developing successful Test System for  
71 aircraft electro-hydraulic actuators is discussed.

## 72 3 II. OVERVIEW OF THE SYSTEM

73 The Moog Portable Test Controller is made user friendly with only having a small amount of control keys  
74 available. The majority of the functions can be controlled through the push/turn knob that is located in the  
75 middle.

76 The test system uses PTC, a digital servo controller to command and control the load and position. It is a  
77 1 to 4 channel digital servo controller with Liquid Crystal Display (LCD). This controller gives the flexibility  
78 to add additional hardware like the digital and analog inputs and outputs that includes vibration inputs, strain  
79 gauge amplifier inputs, remote control units etc.

80 The connection between the SCU's and the real-time front end is established by using a low-cost real-time  
81 Ethernet communication link, enabling the controller to be placed very close to the actuator. The analogue  
82 cabling, usually an expensive and noise prone part of a test system, can be kept as short as possible, introducing  
83 very high signal-to-noise ratios.

84 The Test System has capability to measure Linear Variable Differential Transformer (LVDT) sensor on UUT  
85 (Unit Under Test), to measure the position and communicate as a voltage signal back to the PTC for the  
86 position loop closure. The Acceptance Test Procedure (ATP) test setup is shown in Figure 1. Position Loop:  
87 PTC generally uses the FCSLoop to bind position loop with SCU1.The FCS loop is a Moog unique control loop  
88 with dual mode controller, which allows to switch between force and position control modes. The SCU has all  
89 necessary I/O hardware to connect a typical actuator. Usually this will be a hydraulic, servo-controlled actuator.  
90 Each SCU is connected to its own actuator. It's the job of the controller to modify the output connected to the  
91 actuator in such a way that the feedback is always as close as possible to the commanded value. Host Computer  
92 gives the input command to PTC low level Drivers which will interact with hardware system and hardware system  
93 gives the feedback command to Host Computer through PTC. The functional logic of GUI for Air Purging Test  
94 is shown in Figure ?? . Figure ?? and Figure ?? shows the LabVIEW code of the Air Purging Test for both the  
95 loops respectively. Channell is for Position Loop, which is bound with SCU1 and connected through FCS type  
96 Loop.

## 97 4 Global Journal of Researches in Engineering

98 Channel2 is for Force Loop, which is bound with SCU2 and connected through FCS type Loop.

99 Figure 7 shows the selected PTC channels and Figure 8 shows how these channels bind with respective SCU's.  
100 After binding the loop and LVDT calibration, Tuning has to be performed for better output following with respect  
101 to input commands. A Proportional-Integral-Derivative controller (PID controller) is uses to control the loop  
102 feedback mechanism. PID is the most commonly used feedback controller. A PID controller calculates an "error"  
103 value as the difference between a measured process variable and a desired setpoint. The controller attempts to

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104 minimize the error by adjusting the process control inputs. Figure 12 shows the Position loop tuning. ? Now  
105 apply the null bias servo value offset current to the UUT.  
106 ? Now slightly increase and decrease the offset current to move the UUT in Extend and Retract direction  
107 respectively.  
108 ? Now Set the PID values in such a way that the system will not go in unstable mode. And set the optimum  
109 PID values so that output signal follows the input command exactly or nearly exact.

## 110 5 CONCLUSION

111 The intended test equipment has been built and system software for controlling the test equipment has been  
112 developed in LabVIEW. A new approach used in this paper to test the actuator using PTC hardware. The  
113 advantage of PTC used in Acceptance software is cost reduction of the Testing and the reduction in the  
114 development time. On the basis of this approach and its derivative system design, we can further make different  
test system with large scale testing, which is going to be applied widely in the automation and industrial field.



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Figure 1: Figure 1 :

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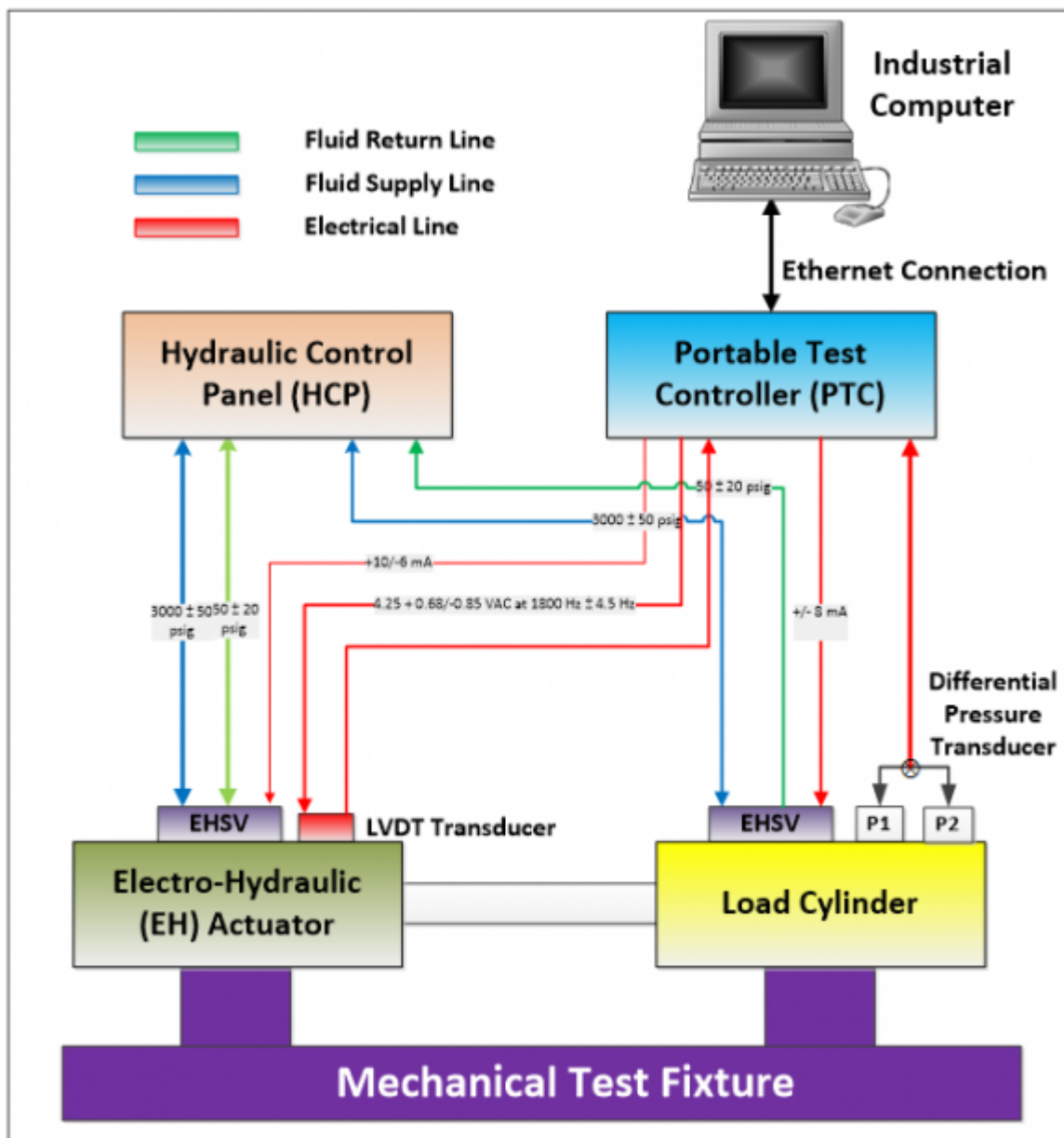


Figure 2:

2

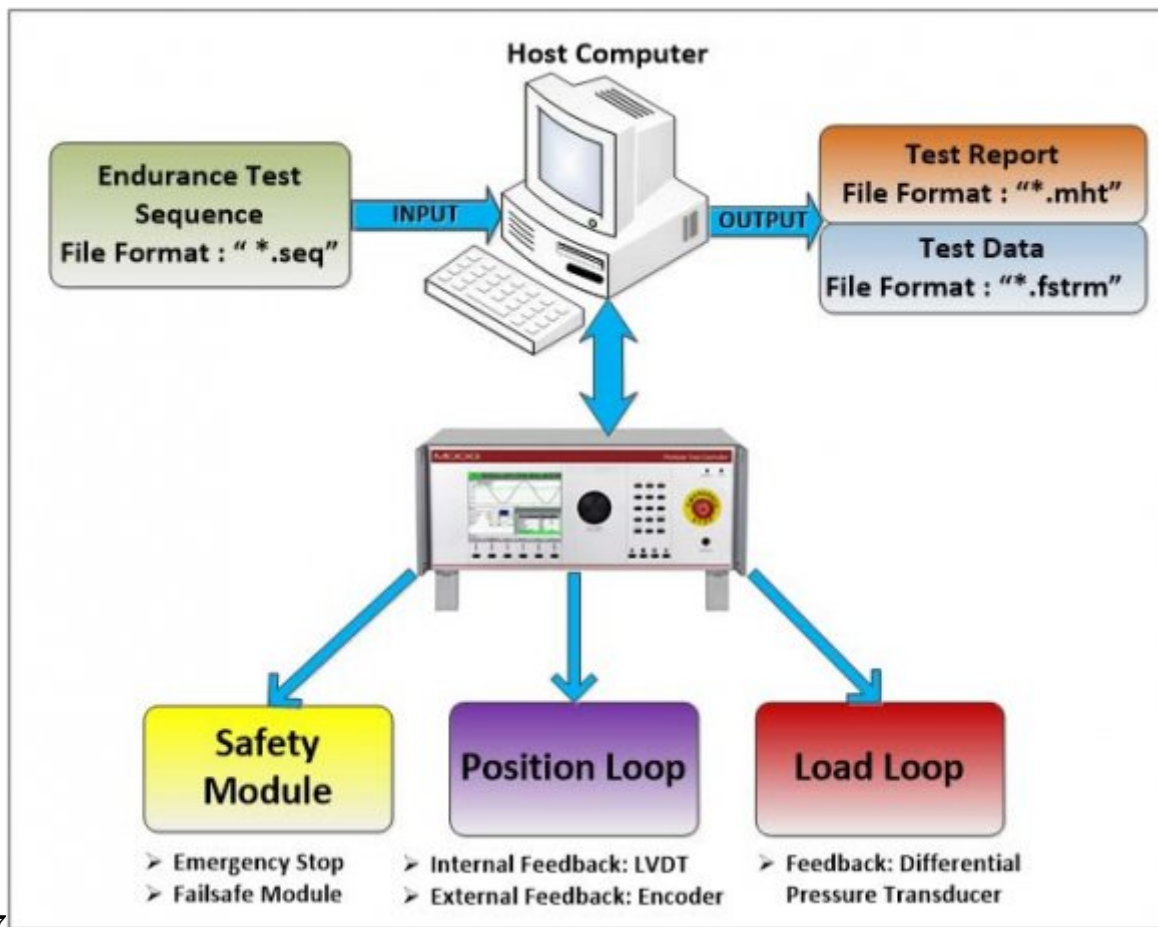
Figure 3: Figure 2 :

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Figure 4: Figure 3 :

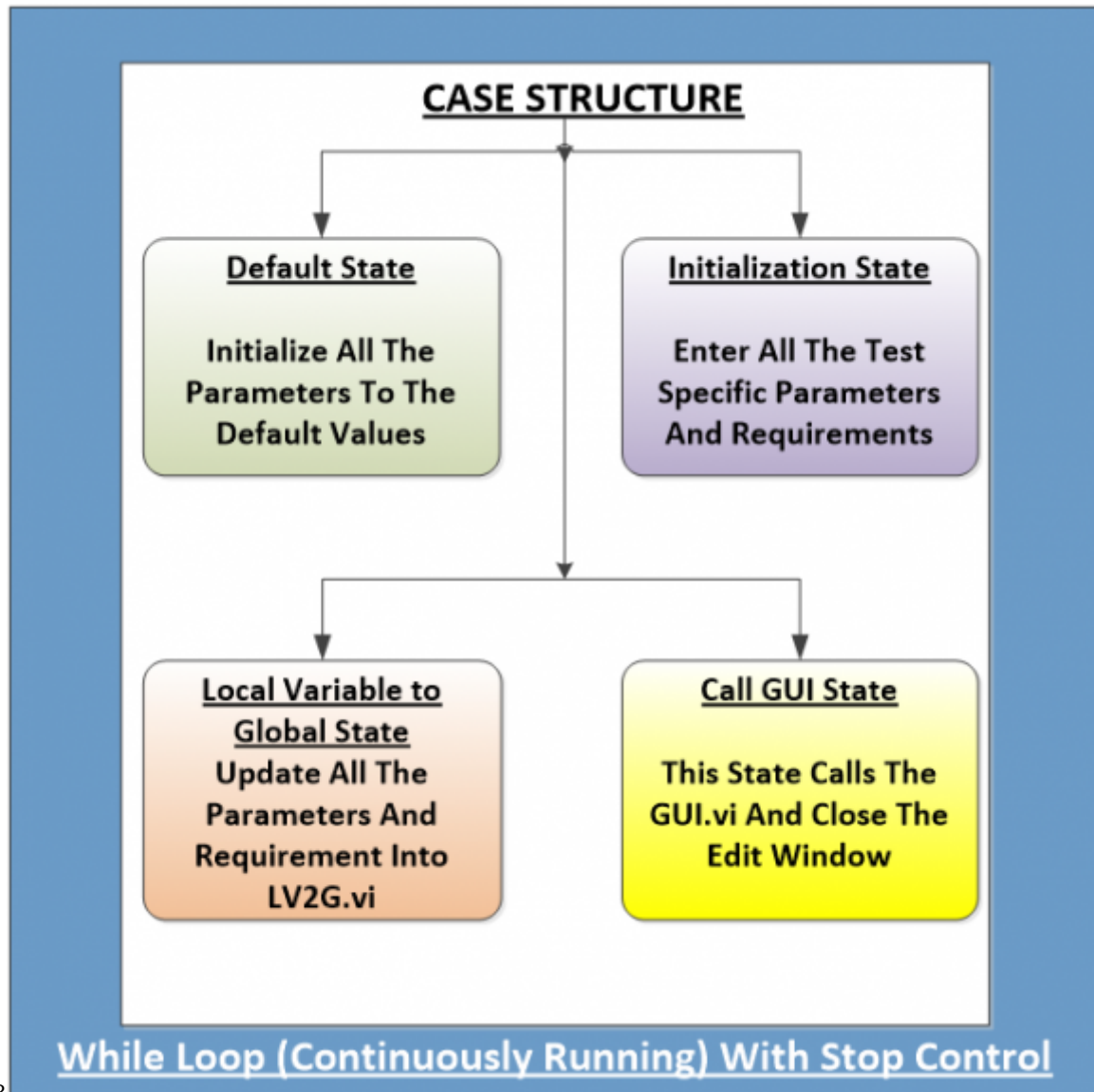
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Figure 5: Figure 4 :Figure 5 :Figure 6 :



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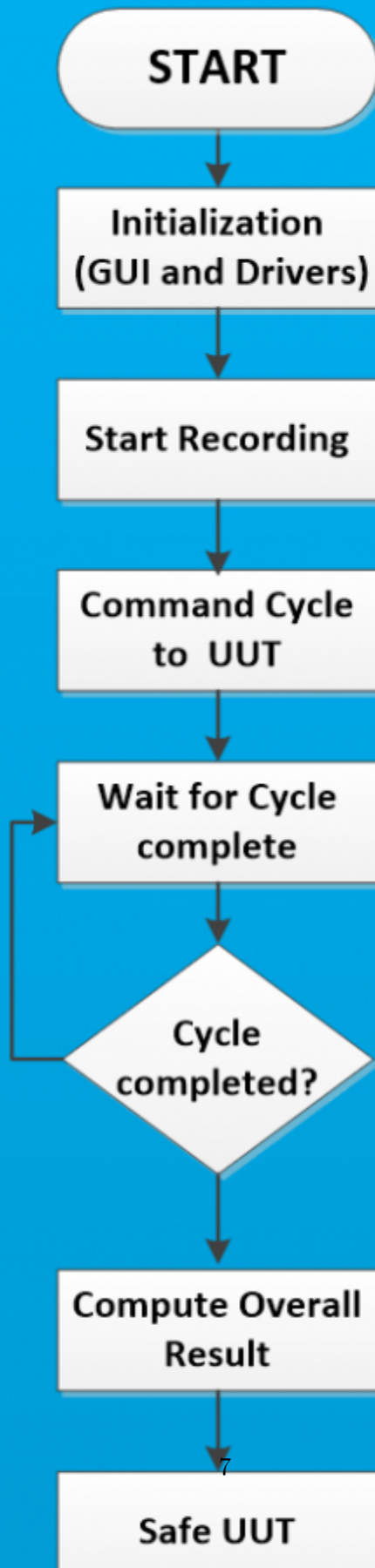
Figure 6: Figure 7 :



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Figure 7: Figure 8 :

Case Structure



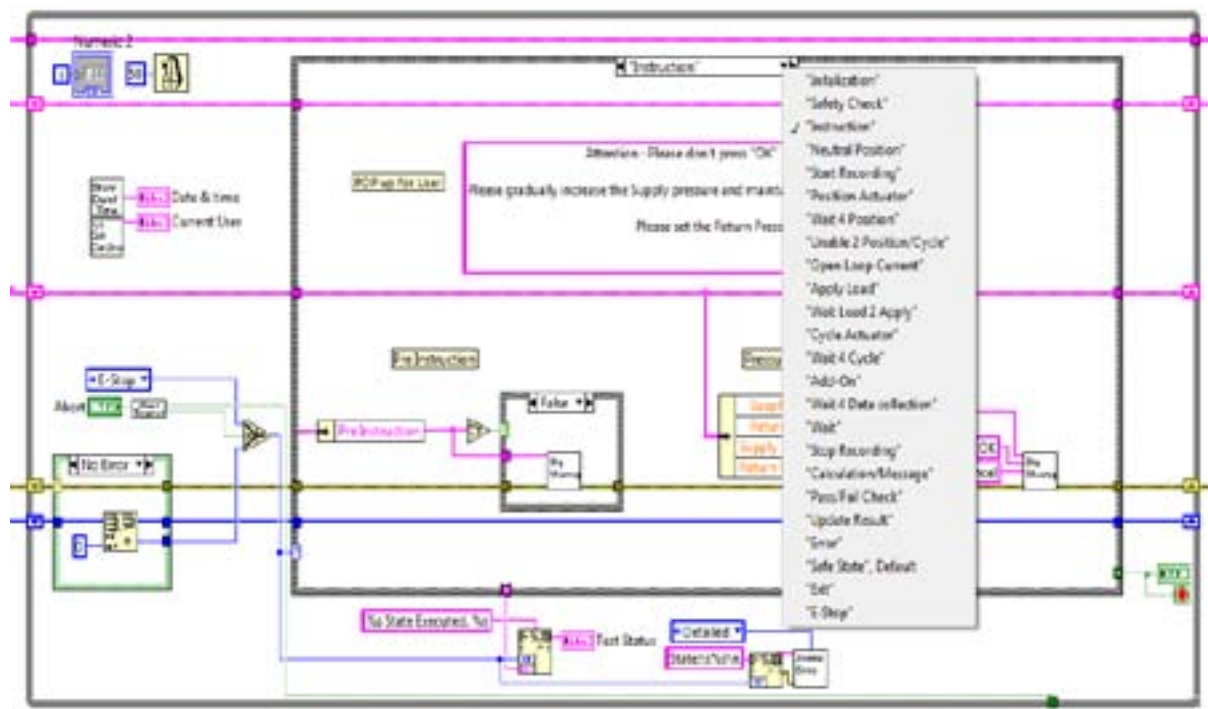
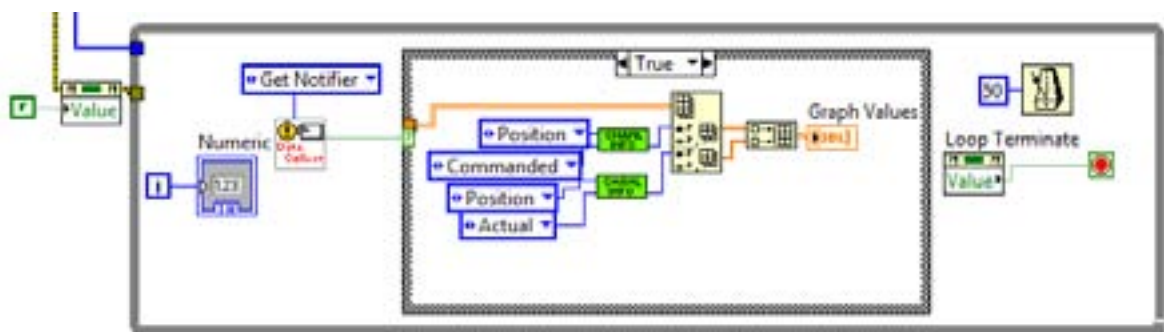
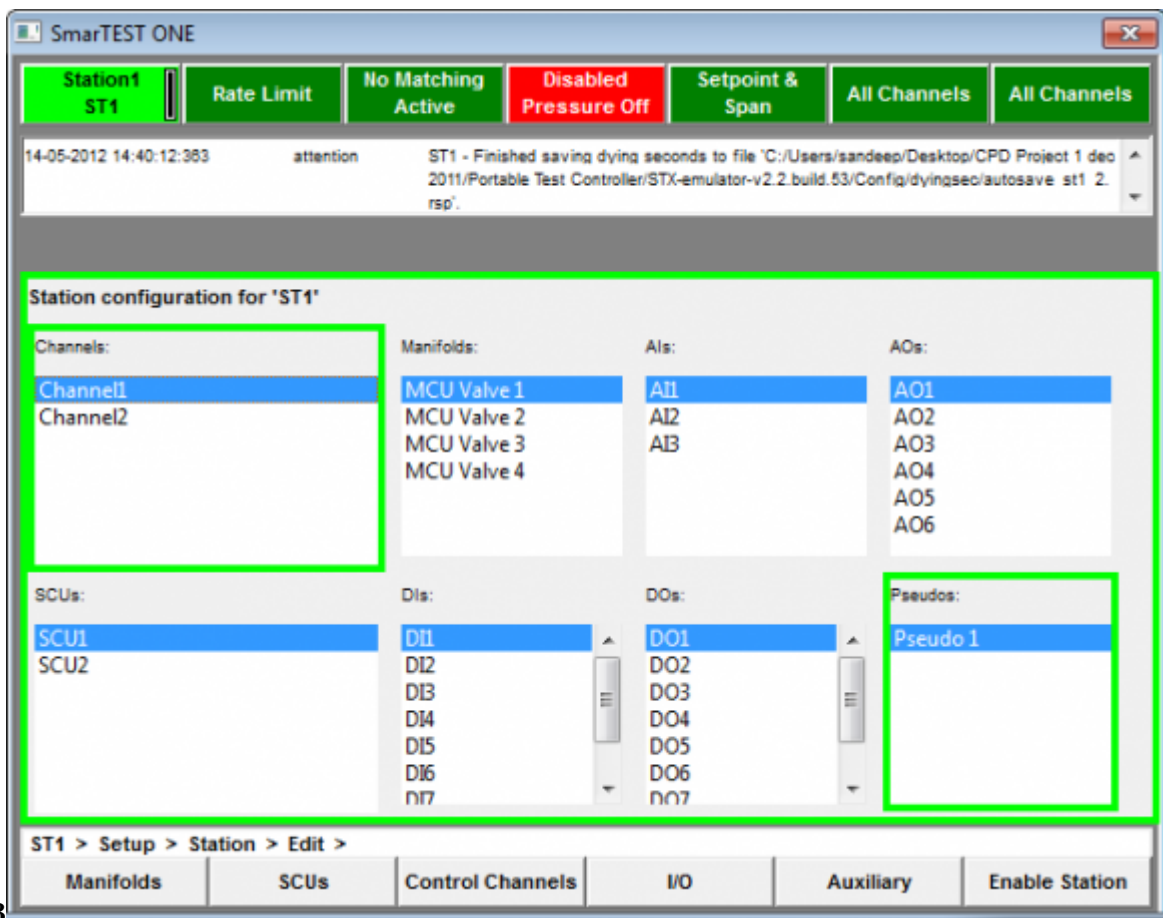


Figure 9:



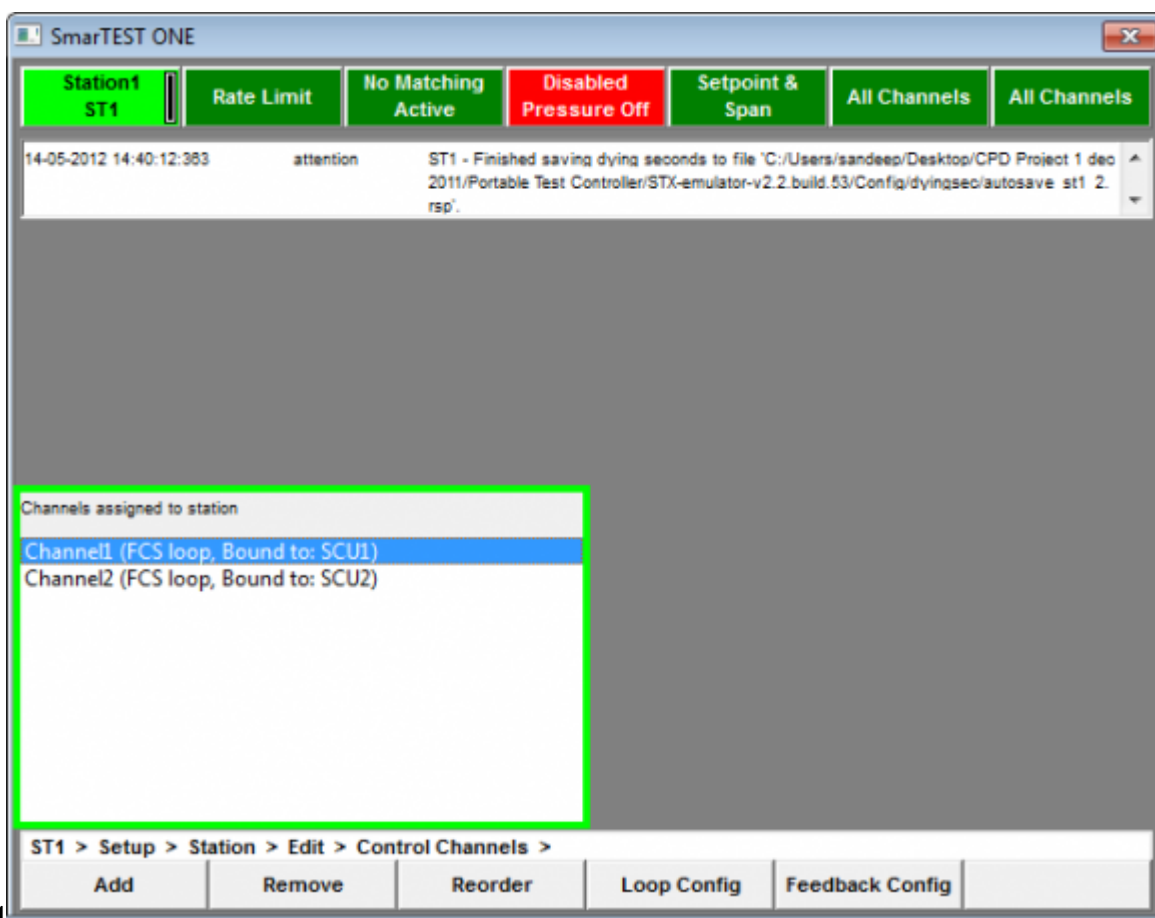
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Figure 10: Figure 12 :



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Figure 11: Figure 13 :



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Figure 12: Figure 14 :

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