Converting the Active Digital Controller for Use in Two Tests

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Modifying the Active Digital Controller for Use in Two Tests

The Active Digital Controller (ADC) was modified for use in the Actively Controlled Response of Buffet Affected Tails (ACROBAT) tests and for side-wall pressure data acquisition. The changes included general maintenance and updating of the controller as well setting up special modes of operation. The ACROBAT tests required that two sets of output signals be available. The pressure data acquisition needed a sampling rate of four hundred hertz, twice the standard ADC rate. These modifications were carried out and the ADC was used during the ACROBAT wind tunnel entry.

The Active Digital Controller is a system used to control the various functions of wind tunnel model. It has the capability of digitizing and saving of up to sixty-four channels of analog data. It can output up to 16 channels of analog command signals. In addition to its use a general controller, it can run up to two distinct control laws. All of this is done at a regulated speed of two hundred hertz.

The ADC

Main Computer

The base computer in the Active Digital Controller (ADC) is a SUN 3/160 Workstation using the UNIX operating system. This system provides the user interface for the ADC. It is also used to store and move the data collected. The SUN runs the information display and storage program as well as the user interface program.

Within the base computer there are three additional processor boards. The integer digital signal processor that is used to run the real time data acquisition and control program. Next is a floating point digital signal processor. This board is used to execute the active control laws and calculate the desired commands based upon the current sensor readings. The last board is an array processor. This was previously used as a back-up board but is now used for memory only. These three boards compose the real-time part of the ADC.

Along with the three processor boards within the SUN there are also four interface boards. The first two of these are analog to digital boards. In total this translates up to sixty-four analog input signals into 12 bit digital values. The second set are digital to analog boards, which provide up to sixteen analog outputs to the model.

The hardware rack used with the ADC contained three major components. The filter box provides for analog signal filtering and antialiasing. Along with the filter box was a patch box to allow the raw unfiltered signals to go to the ADC. The second component is the status display panel. It provided a visible confirmation of various control parameters. Lastly the rack contained an oscilloscope for use in diagnostics.

Programs

There are four main programs that run the ADC, the user interface, the information display and data saving program, the real-time controller, and the control law processor. These programs communicate using shared memory space but are generally independent of each other.

The user interface program is one of two programs which run concurrently of the SUN CPU. All interaction with the ADC is from this program. It starts and stops the real time system and the information display program, and allows the user to interact with the operation of the other CPU boards and their programs. The operator uses this program to change the operating modes of the ADC, operating and changing the parameters of the excitations and control laws, and starting and stopping a data save.

This information display and data saving program provides two functions. It allows the ADC user to quickly and easily see the signals being received. Second it saves the data taken to a file on the SUN computer. The information display window is run by the SUN computer and has an update rate of one to three times per second. The information window is used to get a rough view of the data and its speed is not important.

Operating on the primary real time board, the real-time program controls most aspects of the ADC. It controls the analog-to-digital and digital-to-analog boards to provide input from and output to the model. The program sends the excitations out and collects the incoming data to be saved by the information display and saving program. In addition to this, it also controls the status display board mounted in the rack.

The control law processor runs on the two nodes of the floating point digital signal processor. Its task is to execute the control laws given to it. By using both nodes, multiple control laws can be run at the same time.

Together, all of these programs compromise the software element of the ADC. The real time system can perform all of its tasks namely, acquiring the previous control law and excitation outputs, sending these outputs to the model, reading in new sensor signals, computing the control inputs, running the control laws, storing data, and other housekeeping tasks within a five millisecond time frame. This allows the real time components to achieve a two hundred hertz sampling rate that is adequate for most control needs.

Overview of the ACROBAT Tests

The ADC's most recent use has been in the Actively Controlled Response Of Buffet Affected Tails (ACROBAT) test runs. The test deals with the tail buffet problems of the F-18 during high angle of attack maneuvers. During these maneuvers, vortices from the wing-fuselage interface cover the two tails on the plane. By using active controls on the rudder, one of four other smaller control surfaces, or piezoelectric actuators on an internally warped tail, it was hoped that the buffet could be alleviated.

The ACROBAT tests ran using a one sixth scale F-18 drop model. The model was sting mounted to provide an angle of attack range of seven to thirty-seven degrees. An internally mounted hydraulic actuator provided actuation of the rudder and other control surfaces. A servo control rack was used to provide position and hydraulic pressure feedback to the hydraulic servo actuator. After calibration, this control system provided excellent correlation between the commanded and the actual movement of the actuator. The piezo-electric packs were activated from a piezoelectric control box designed for that purpose.

The test was run in NASA Langley's Transonic Dynamics Tunnel from July 10 to July 28. The model was flutter tested up to a maximum dynamic pressure of 18 pounds per square foot and 0.1 mach. Standard test runs were conducted at 14 psf. and 0.1 mach.

Changes in the ADC

There were three major types of changes made in the ADC and its programming. First, some changes were of the general maintenance and upgrading variety. Second, the ADC was configured to run during the ACROBAT tests. Third, a special mode was set up to acquire data for an ongoing project. This project was to take data from eight side-wall pressure transducers in the Transonic Dynamics Tunnel.

General Changes

To upgrade the ADC program a few features were added. First the number of output signals could be changed at will. Outputting signals is a very time consuming process and in order to keep the real time processor at 200 Hertz in all modes, the number of outputs needed to be selectable. The code was changed so that all excitations sent started at the beginning of the excitation. A new information display was set up that would display thirty-two channels of information at one time. There were many more small maintenance changes made. These changes include better command names, cleaner looking displays and other beautifications. Also the code was cleaned up in places to allow for faster running.

ACROBAT changes

The ACROBAT tests demanded a few changes be made in the ADC. First two sets of output actuators were needed. One set was for the control surfaces. The second was for the piezoelectric tail. This was accomplished by using two data files and an option to switch the two. Many of the changes in the upgrade area were prompted by ACROBAT needs, such as changing the number of actuators. Finally different data scaling files were set up to scale the input and output signals correctly.

Pressure Data Acquisition Changes

The data from the pressure transducers was needed at at least 400 Hertz. This required work to streamline the code for this mode of data acquisition. The number of input signals in one mode was lowered to allow for faster running. In the same mode the output options were disabled. Also for this project a remote triggering mechanism was set up. This required setting up an input trigger signal as well as an output to provide voltage for such a signal. Upon receiving a voltage in the input signal a data save was executed and the ADC readied for another similar data save. An additional new feature was also added for this test. A monitor system was installed that would send an alarm if the tunnel was at the desired conditions to collect pressure data.

Actual Use of the ADC

During the test run the Active Digital Controller worked very well. Few problems were encountered. Most of the errors during the test were caused by human error. This improved as the operator gained experience. There were few other problems and these were quickly fixed.

Overall the test went well in terms of the ADC's involvement. Besides taking general data about the functioning of the model, a few control laws were implemented during the final third of the test. These control laws will provide a basis for which the next ACROBAT entry can be planned.

An initial set of data has been taken for the side-wall pressure data. This data came from the wind tunnel entry prior to the ACROBAT test. This data has gone through basic analysis and more data will be taken in the future.

Future of the ADC

The ADC has at least two more projects left in its operating life. First is the second wind tunnel entry of ACROBAT. This test is scheduled for late November and is to concentrate on more control law testing. Also the pressure data acquisition has not stopped and the ADC will continue to take data for that project.