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# Airframe Testing

## Application Note 1270-8



### Applications

Military Aircraft  
Commercial Aircraft  
Helicopters  
Business Aircraft

### Departments

Research and Development  
Production  
Quality Assurance  
Regulation Compliance

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### Description

A newly designed aircraft must be thoroughly tested before it can be flown. Hydraulic stress testing is a common technique for checking the strength and flexibility of wings, fuselage, propellers, and entire airframes. Tens or even hundreds of hydraulic actuators push and pull at an airframe to test for failures and materials fatigue that might occur under flight conditions. Strain is measured at hundreds of points to qualify test results.

### Problem

To simulate actual test conditions, each actuator must be controlled independently yet synchronously with all of the other actuators. Actuator force must be updated many times per second to simulate dives and turns. To avoid destroying expensive prototypes, limit checks must be used to cut power to the actuators in case force or travel maximums are exceeded.

### Solution

An automatic Data Acquisition System coupled with a real-time computer can provide a flexible, reliable solution for this application. Depending upon the hydraulic actuation system, analog or digital outputs are used to control the actuators. Each output can be individually programmed and still change in synchronization with other outputs. Actuators can be under closed-loop control by sensing applied voltage, monitor linear actuator motion with LVDTs (Linear Variable Differential Transformers), and/or measuring the strain caused by actuator force. Digital I/O channels are used for safety interrupts, reading and setting test conditions, and checking limit conditions.

## Implementation

### Strain

Strain measurements are used for two purposes. When taken from load cells attached to actuator arms, strain data serves as feedback to the actuation system. This feedback is used for closed loop control of the actuators and as a limit check to ensure that maximum force limits are not exceeded. Force limits prevent unintentional damage to the device under test (DUT). Strain is also the major indicator of DUT performance. As the DUT is contorted by the actuation system, strain is measured at hundreds of points that create a map of how the DUT is responding to the applied forces. Some tests are designed to increase force until rupture. Fatigue tests will repeat force patterns for thousands of iterations to test for reliability.

Instrumentation: Integrating DVM,  
Relay Strain Gage  
Multiplexer,  
High-Speed DVM,  
FET Strain Gage  
Multiplexer

### Analog Output

For actuation systems that apply force proportional to a DC input voltage, digital-to-analog converters are good input sources. D/A converters can be incremented in very small steps. The rate of change as well as the final value can be easily controlled with simple programmable routines.

Synchronization is important for realistic simulation of flight conditions, all applied forces must change in unison. A D/A converter with dual-rank programming provides this capability. All channels are updated serially but actual output does not change until a trigger signal is applied. Applying the trigger signal to all channels simultaneously causes the synchronization update.

Instrumentation: Voltage D/A Converter

### Digital Input

Digital Inputs are used to detect limit switches, power loss, hydraulic pressure loss, and other alarm conditions so that testing can be shut down to prevent damage to the DUT.

Instrumentation: Digital Input

### Digital Output

If the hydraulic actuation system is digitally controlled, digital outputs will be the primary data acquisition system output. The same considerations of small steps and synchronization control for analog outputs apply here too.

Instrumentation: Digital Output

### Analog Input

Often the analog voltage applied to the actuators is measured as a way of monitoring system performance. Comparing this voltage to measured strain for a particular channel can verify calibration of the actuator. Monitoring applied voltage is also the first level of limit checking to ensure that DUTs are not damaged.

Instrumentation: Integrating DVM, FET  
Multiplexer

## Key System Features

- Downloadable Subroutines
- Interrupt Handling
- Limit Tests
- Multi-tasking Subroutines

## Typical System Configuration

Data Acquisition System	Qty
13 Slot Mainframe	2-10
Integrating DVM	1
High-Speed DVM	1
Strain Gage Channels	20-120
Voltage D/A Converter Channels	20-120
Digital Inputs	16-256
Digital Outputs	16-48
FET Multiplexer Input Channels	20-120

## Computer/Software

- Embedded VXI Controller
- Keyboard, Monitor and Mouse
- Disc Drive and Printer
- Software - HP-UX and HP VEE