

FLUTTER EXCITATION SYSTEM

The purpose of a flutter exciter is to impart vibration to a structure. An excitation system, carried by the flight test aircraft, introduces energy into the aircraft structure to excite its natural modes.

During flutter flight testing, these structural vibrations are measured using accelerometers and the responses are used to determine whether flutter onset is likely. A flutter excitation system improves the signal-to-noise ratio of the accelerometer responses and provides higher-fidelity structural data. The flutter exciters used by the CSIR include:

- Bonkers – Explosive charges that provide a single excitation. These were used on Buccaneers, Impalas, Mirage F1's and so forth;
- Rotating cylinder exciters – The CSIR co-developed this type of flutter exciter. The rotating cylinder provides excitation over a programmable frequency range and duration; and
- Annular wing exciters – This type of system is currently used on civilian and high-speed military aircraft. The annular wing excitation system provides excitation over a programmable frequency range and duration.

Overview of the system

The flutter exciter system (FES) includes a port exciter, starboard exciter, cockpit control unit (CCU) and a 27 VDC, 11.7 A ground station, with associated cables.



Typically, a logarithmic sweep from 1 Hz to 40 Hz is performed. The exciter is compact enough to be fitted into a store and, therefore, does not influence the flutter characteristics of the store configuration being cleared. Vertical (Z) and lateral (Y) excitation forces are measured using two full strain-gauge bridges. The strain-gauge signals are amplified on board (gain 500, cut-off frequency = 50 Hz). Feedback to the pilot is provided through the Liquid Crystal Display (LDC) screen of the CCU and Light Emitting Diode (LED) indicator lights.

Exciter

The exciters comprise:

- An annular wing to induce oscillating loads;
- An electric motor, with an integrated onboard motion controller, to drive the annular wing; and
- Two full strain-gauge bridges and associated electronics, housed at the rear of each motor, to receive encoder signals used to drive the motors through a differential encoder line receiver, strain-gauge amplifiers and a DC-DC converter to power the circuit.

CONTACT: Bhavya Vallabh | E-mail: bvallabh@csir.co.za

www.csir.co.za



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Cockpit control unit

The CCU consists of:

- An embedded control computer to communicate with each exciter and record frequency-sweep data;
- Indicator lights and an alphanumeric display to inform the pilot of the system's status;
- A motor controller and master electric motor with an integrated encoder to generate a control signal for the port and starboard flutter exciters;
- A start button to initiate a frequency sweep and a stop button to abort a frequency sweep, if necessary;
- A frequency-sweep mode switch to select either symmetric or anti-symmetric excitation;
- A master switch and abort button, either of which can be used to cut power to the FES should the need arise;
- An additional external abort switch that performs the same function as the master switch and primary abort button;
- A circuit breaker to limit the system's current draw and act as an additional emergency switch when pulled;
- A ready (green) light to indicate to the pilot that the motion control computer has booted up correctly and that a frequency sweep can be initiated;
- A busy (yellow) light to indicate that the flutter exciter motors are rotating the annular wings according to a frequency s-weep profile;
- An error (red) light to indicate that a problem with the FES has been encountered or that the maximum current draw of the motors has been exceeded; and
- A 20 x 2 alphanumeric display to indicate certain parameters to the pilot, such as the frequency-sweep start frequency, end frequency, period and progress.

Ground station

The ground station setup includes the following components:

- Ground power supply;
- CCU and two exciters;
- USB mouse and keyboard;
- Computer monitor; and
- Various cables.

Control software

The source code is written in Microsoft Visual C++ 2008. There are three separate threads:

- Main thread – Required for the initial setup and to ensure that the program runs indefinitely;
- Motion control thread – Controls the motors and acquires; this thread has the highest priority; and
- Digital Input Output thread – Monitors switch inputs and operates the indicator lights.

A terminal program running on a computer is used to configure the master and slave motors.

Basic functionality

The port and starboard flutter exciter motors are slaved, with the master motor housed in the CCU. The flutter vanes or annular wings are positioned for symmetric or anti-symmetric excitation using optical switches.

Symmetric excitation starts with the exciter vane bars in a horizontal position, while anti-symmetric excitation starts with the exciter vane bars in a vertical position. An error is indicated by an illuminated red LED if the current draw of either motor exceeds the set limit.

There are four methods of stopping or aborting a sweep in an emergency:

- STOP button – Software stop;
- ABORT button – Cuts power;
- Master switch – cuts power; and
- Master 15 A circuit breaker – cuts power.

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