Automated Position Setting of Aircraft Canard-Units in Wind-Tunnel Models with LabVIEW™

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Category:
Aerospace/Defense

Products Used:
LabVIEW 5.0.1
PCI FlexMotion-6C

The Challenge:
Automation of an existing manual procedure for setting stepping motor positions of aircraft canard-units in wind-tunnel models with an user-friendly hard- and software solution.

The Solution:
Using National Instruments LabVIEW and the FlexMotion stepping motor controller in combination with a WindowsNT based computer system to provide a cost-efficient robust system for high-precision automated position setting.

Abstract
The development of aircraft-systems requires exhaustive and cost intensive measurements including modeling activities based on wind-tunnel tests. For the analysis of air flow involving a Daimler Chrysler Aerospace (DASA) aircraft model, wind-tunnel experiments with preset canard-unit positions will be performed. Thereby the desired position must be maintained with highest precision.
The current procedure calls for a manual setting of the stepping motor position for the canard-unit, visualized by a LCD panel. This solution is inaccurate, not reproducible and a comparison with related measurement data is impossible because of absent data acquisition.
IFU has developed a powerful hard and software solution, based on National Instruments LabVIEW and the FlexMotion stepping motor controller. This allows an automated online position to be set with an accuracy of better than 1 mrad and, furthermore, enables data acquisition and remote control.

System Requirements
For the analysis of aerodynamical effects at preset positions of the canard-unit, DASA uses a Eurofighter EF-2000 model (scale 1:15) during wind-tunnel experiments as shown in Figure 1.

Figure 1: The wind-tunnel model of the Eurofighter with the canard-unit at the fuselage

To adjust the canard-unit during the wind-tunnel experiment, a two phase stepping motor with 400 half steps, a harmonic drive gear (ratio 100:1) and a special canard-unit gear (ratio 2.43:1) are installed in the fuselage of the model. The position determination was realized by a potentiometer and the end positions are detected by two limit switches. The whole model is mounted on an adjustable frame. All control and sensor cables connecting the model to the separated test stand are fed through the holding frame.

With particular preset canard-unit positions during the wind-tunnel experiments, the model angle will be continuously changed by the adjustable model holding frame. This holding frame is computer controlled by the central controlling unit of the wind-tunnel. Its purpose is to maintain the desired canard-unit position with highest precision.
Traditionally an operator was responsible for the manual setting of the canard-unit position during the movement of the model with a stepping motor controller located in the test stand. The actual position was visualized by the operator on LCD panel and manually readjusted. The maximum wind speed during wind tunnel experiments is 1.5 mach. The axis of the canard-unit is thereby exposed to an aerodynamic torsion moment up to 7.2 Nm. This procedure has the following disadvantages:

- Positioning is inaccurate and slow because the high frequency vibrations could not be properly balanced
- Position determination is inaccurate because of the temperature-dependent delay of the potentiometer
- Due to the lack of instantaneous and automatic data acquisition and visualization of all relevant parameters it is impossible to make reproducible position settings

Therefore this procedure must be significantly improved meeting the following requirements:

- Robust and highly precision computer based solution
- Easy-to-use and modifiable software with a well defined operator interface
- Adaption of the motor control to the reusable canard-unit drive system (custom-specific fitted to the model)
- Improvement of the position determination by replacement of the temperature-dependent potentiometer
- Automatic setting of the canard-unit position with an accuracy of better than 2 mrad
- Remote control of the system from a central controlling unit by a serial connection
- Data acquisition and storage during the experiments in comma-separated-values (CSV) ASCII files
- Supervision and logging of all system parameters and events

System Solution
With respect to the need of our customer and in order to get an easy-to-use and modifiable software and a powerful, but cost-efficient system with short development time, we choose National Instruments LabVIEW and WindowsNT as the software platform. The hardware consists of a National Instruments PCI FlexMotion-6C plugged into a standard PentiumII/450 MHz computer and the stepping motor power device SINCOS from Phyton. The potentiometer was replaced by a shaft-position-encoder ROD 1020 from Heidenhain which supports a standard resolution of 3600 lines per revolution with minimal extensions. To achieve the required resolution of better than 2 mrad we use both phases of the shaft-position-encoder which increases the resolution four times. With an easy connection of the shaft-position-encoder, the re-used canard-unit drive system and the limit switches to the FlexMotion it is possible to assemble a cost-efficient and problem-free hardware.

The stable and robust software functionality can be guaranteed by designing the sofware using the multithreading capabilities of LabVIEW which means parallelism of user interaction, remote control, error handling and data acquisition. The real-time part for the high precision and fast position setting was easily realized by using the DSP of the FlexMotion. The design of the operator interface was developed with respect to the special requirements of the busy measurement environment during wind-tunnel experiments, as shown in Figure 2. The operator interface, reduced to the necessary display elements, enables a fast and easy control of the measurement course but is still open for access to all system parameters by interactive menu driven dialogs.

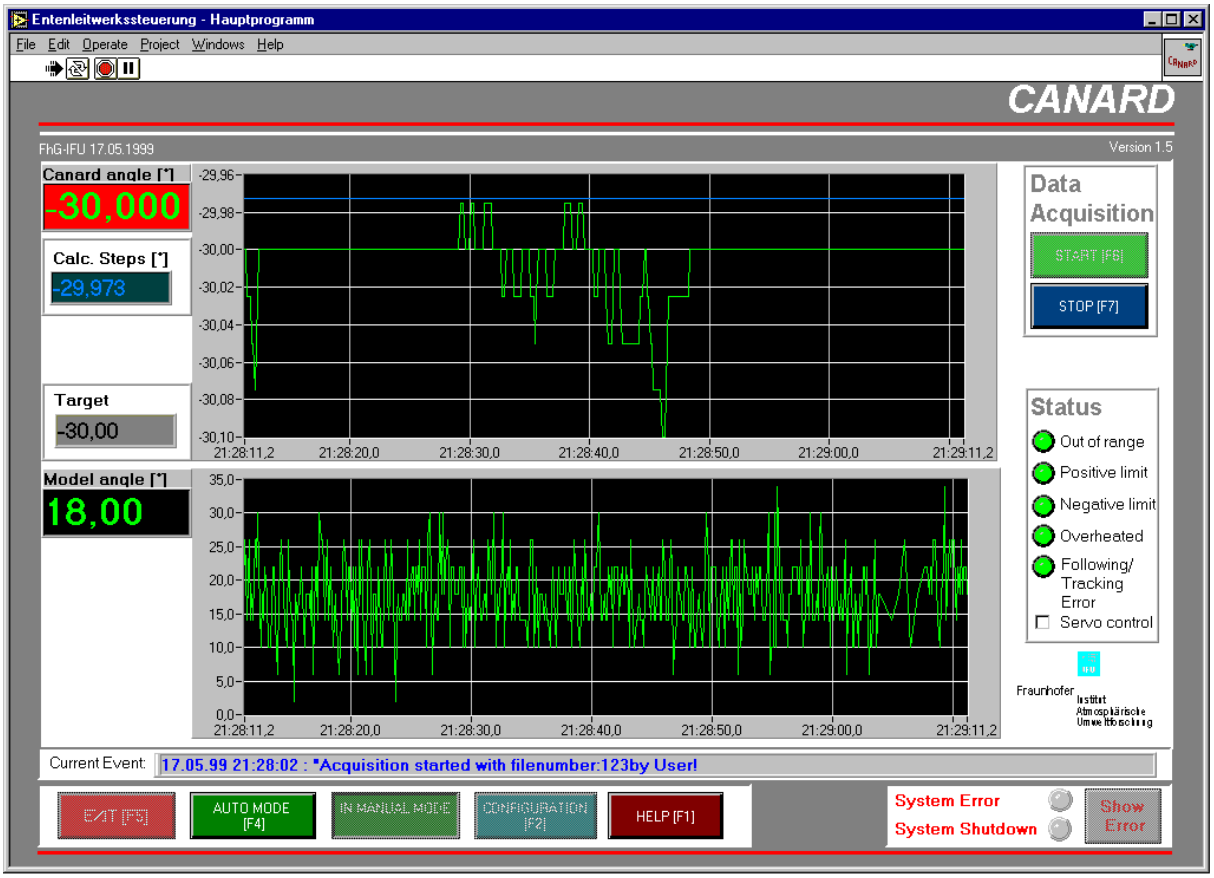

Figure 2: Operator Interface of the CANARD Software

The data are user-configurable analyzed online during the data acquisition by the statistical functions of LabVIEW and stored for further analysis with other necessary system parameters and the correlated model angle in CSV ASCII files. The configuration and setup values are stored and easily readable in standard Windows INI files, so the system can restart without loss of information. All functionality of the system can be consistently and safely handled by the user interface or by remote control from central controlling unit via serial communication (for integration in higher level processes), or both simultaneously.

We designed this system specifically for the Eurofighter model, but the combination of National Instruments easily configurable hardware, and the benefits of its graphical programming environment LabVIEW ensure that this solution can be easily adapted to other applications.

Conclusion

The LabVIEW, FlexMotion and WindowsNT combination has proven to be a very stable environment for the real-time application described here. The operator required for the traditional procedure can now concentrate with our new system on the main control of the experiment. The development costs of this new system are nearly negligible with respect to the wind-tunnel rates. The system was successfully tested during three long-term experiments in the USA and the United Kingdom, and demonstrated an accuracy of better than 1 mrad. Our solution increases the measurement quality of wind-tunnel experiments and its accuracy while also lowering the costs for the necessary measurements.