ADI APPLIED DYNAMICS INTERNATIONAL

Jet Engine HIL Simulation for Electronic Control System Testing

Successful jet engine development depends as much on the quality of the electronic engine control system as it does on engine design. Hardware-in-the-loop testing puts an engine control system through test scenarios identical to those carried out in engine test stand testing, with substantially lower cost, reduced risk, and less burden on human and mechanical resources.

INTRODUCTION

Real-time hardware-in-the loop (HIL) simulation takes simulation further into the jet engine control system development process by providing advanced capabilities for engine testing and emulation.

The success of a jet engine program is as closely tied to the quality of its Full Authority Digital Engine Controller (FADEC) as it is to the quality of the mechanical engine design. The FADEC is a jet engine's brain, controlling precise fuel delivery while providing complete redundancy for safety-critical reliability.

A FADEC may be conceptually partitioned into two systems: the operating system and the application system. The operating system includes not only the real-time operating system software (or scheduler) but also all mechanical and electronic hardware that comprises the FADEC, all software device drivers required to expose the electronic capabilities, and a software interface to the application system.

The application system includes software to provide control algorithms, fault detection, and performance monitoring. The application system code may be hand written, typically in C or Ada, or more recently, automatically generated model-based code. The application system is responsible for a particular engine's balance between fuel efficiency, maximum thrust, and engine noise. By changing the control algorithms in a FADEC's application system, two identical engines can provide very different behavior tailored to the engine customer.

FADEC development provides an interesting challenge. Today's competitive aircraft engine market requires that FADEC development begin while the intended engine is still on the drawing board. Likewise, FADEC testing must begin far before a prototype engine is made available. An additional obstacle for FADEC development arises due to the high cost of each engine. Before a prototype FADEC is ever strapped to a prototype engine, the engine manufacturers must be confident the FADEC will work as designed. A FADEC design or implementation error resulting in damage to an engine is an unacceptable risk. Additionally, all major jet engine manufacturers use outsourcing to supply either the complete FADEC or the FADEC OS.

To assure reliability, FADEC testing must:

✛ Start early in the development cycle
✛ Include an accurate representation of the engine
✛ Provide thorough coverage of the test domain
✛ Be available to both engine manufacturer and FADEC supplier.

To accomplish this goal, hardware-in-the-loop (HIL) simulation testing is required.

PRODUCT OVERVIEW

SIMsystem: ADI's Powerful Real-Time HIL Simulation Solution

Since 1957, Applied Dynamics International (ADI) has been in the business of designing and manufacturing computer-based solutions for real-time HIL simulation of complex, dynamic systems. No other simulation solution provider has a longer history of supporting HIL simulation for new product development and testing.

ADI's SIMsystem real-time testing platform is the world's most widely and successfully used HIL testing platform for FADEC development and testing. Engines ranging from the small Tay-611 found on the Gulfstream GIV to the giant Trent 900 soon to be found on the mammoth Airbus A380 are developed and tested using the SIMsystem. Rolls-Royce's ability to meet Airbus's aggressive A380 FADEC delivery deadline is an indication of the company's leadership position in the aeroengine market. Part of this success is due to their use of the SIMsystem.
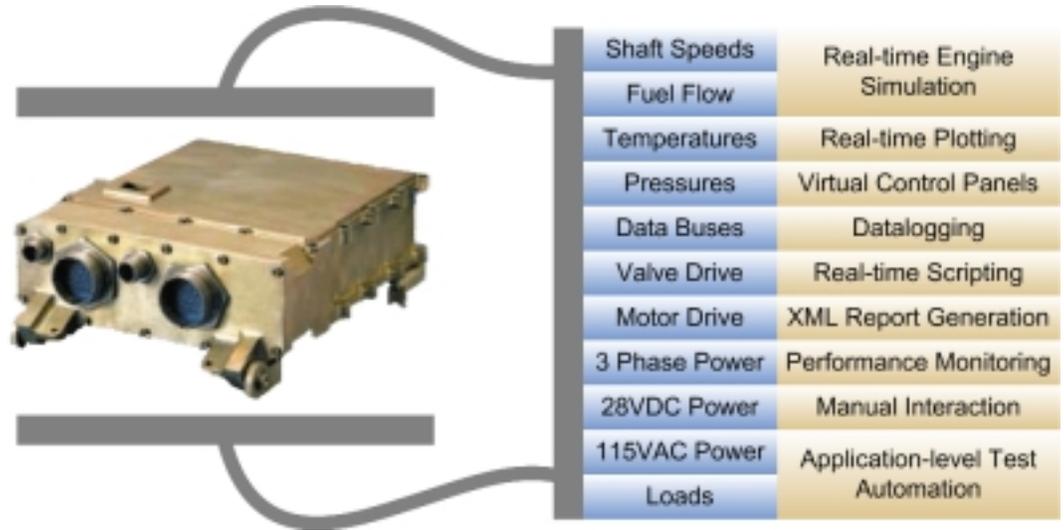
SIMsystem Provides Important Benefits for Engine Simulation Using HIL

SIMsystem provides a complete jet engine simulation / emulation, allowing a prototype or production FADEC to be connected to the HIL system through standard connectors and run through any number of simulated engine tests. A high fidelity real-time engine model is simulated with a step time of 1ms or lower. Electrical signals including sensor emulation such as shaft speeds; databus communication such as ARINC 429; and motor and valve drives, are initiated by both the engine model on the HIL system and the FADEC.

HIL testing using SIMsystem puts the FADEC through test scenarios identical to those carried out in engine test stand testing. Although the HIL test results will be effectively identical to the test stand results, the cost of HIL testing is substantially lower.

In addition to the reduced burden rate of the test equipment, HIL testing avoids problems such as fuel handling, exhaust gas handling, and health and safety concerns.

Automated HIL tests require fewer test engineers and can even run unmanned overnight.

Shaft Speeds	Real-time Engine Simulation
Fuel Flow	
Temperatures	Real-time Plotting
Pressures	Virtual Control Panels
Data Buses	Datalogging
Valve Drive	Real-time Scripting
Motor Drive	XML Report Generation
3 Phase Power	Performance Monitoring
28VDC Power	Manual Interaction
115VAC Power	Application-level Test Automation
Loads	

The SIMsystem software provides all the features required for effective FADEC development and testing using hardware-in-the-loop simulation.

SIMsystem Software Tools

The SIMsystem HIL test platform includes ADI's ADvantage software, providing all the tools required for FADEC testing.

The combination of ADvantage software with the RTS real-time hardware results in fast test project setup, easy project debugging, powerful real-time scripting for test repeatability, and fully extensible test interaction and application-level test automation. All these factors result in faster and more reliable FADEC development.

The Advantage Toolset

A fundamental benefit provided by ADI's ADvantage software is the ability to run a jet engine model with millisecond-level determinism. To complement HIL performance requirements, ADvantage includes performance measures enabling testers and test developers to examine the real-time performance of the HIL simulation. The test developer must ensure that real-time determinism is maintained throughout the duration of the test.

Run-Time Debugging
To further aid test development, ADvantage includes a full-featured run-time debugger used to troubleshoot problems found in customer jet engine models.

Other real-time HIL features required to meet the repeatable testing requirements of the FAA's DO-178B and other safety-critical standards are real-time data logging and real-time scripting.

Real-Time Data Logging

ADvantage real-time data logging uses compact, high-performance, real-time data acquisition system (DAS) components enabling tests to log data at microsecond-level rates and accuracy.

Real-Time Scripting

ADvantage Test Choreographer is the most powerful real-time scripting engine available, enabling test scripts to be executed with microsecond-level determinism.

AdvantageDE

To round out the test platform, ADvantage includes the Windows-based software AdvantageDE to develop test projects using point-and-click.

AdvantageVI

ADvantageVI allows users to interact with, automate, and visualize a real-time test at run-time.

SUMMARY

The SIMsystem real-time simulation platform is ADI's answer to the aeroengine industry's need for powerful, flexible, HIL simulation and test automation tools for fast, reliable, low risk FADEC development.

To stay at the forefront of jet engine design, today's engineers need the best tools.

HIL testing using the SIMsystem real-time simulation system allows engineers to subject the FADEC to test scenarios identical to those carried out in engine test stand testing at substantially lower cost, with less burden on test equipment, and with fewer health and safety concerns.

SIMsystem's real-time hardware and software results in fast test project setup, millisecond-level determinism, easy project debugging, powerful real-time scripting, fully extensible test interaction, and application-level test automation for faster and more reliable FADEC development.

For more information about how SIMsystem can reduce FADEC development time and cost, reduce risk, and optimize test efficiency, please contact us at:

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ADI APPLIED DYNAMICS INTERNATIONAL

For over 45 years, Applied Dynamics International (ADI) has been a global supplier and developer

of state-of-the art software and hardware tools for the design and test of embedded control systems

used in the automotive, aerospace, defense, and power generation industries.