Research Paper
International Journal of Aerospace System Engineering
Vol.1, No.1, pp.10-15 (2014)
ISSN 2383-4986

Development of Operating Program for EECU Test Bench

Myoungcheol Kang† , Seonghee Kho and Jayoung Ki
EGT Co., Ltd.

Abstract : This study presents technical description of the operating program development that operates the test bench for functional test of EECU. The test bench is capable of testing, simulation and adjustment of the EECU software using the operating program. The test bench is for the Development Project of the EECU platform for FADEC system.
The operating program is consists of 3 modules which are the test bench operating module, cockpit simulator module and SILS module. The operating module mainly carries out the EECU test with manual operation and operating scenarios. Also that record and process the test data. The cockpit simulator module is capable of implementation of virtual cockpit control input and engine status display. The SILS module can simulate engine and EECU operation in software environment.

Key Words : EECU(Electric Engine Control Unit), FADEC System, Test Bench

1. Introduction

The Full Authority Digital Engine Controller (FADEC) as the latest control technology for aircraft engines is the system, in which an electronic controller has all the authority to control over the engine, and its core component is called the 'Electronic Engine Control Units' (EECU).

Since EECU has control over the level of fuel or status signal for engine by pilot's operation signals, it plays a practically main function role of FADEC. [1,2] As stated, EECU is classified as an item of national-level protection required and its development company as well in advanced countries since it is perceived as the core component of aircraft engines and as the brain of engine requiring cutting-edge technology, so it is very difficult to receive technology transfer.

The test bench is an essential equipment for verifying EECU in development, and for the real-time test of control algorithm during the process of developing EECU. In addition, it can reduce time and costs for developing a product since it decreases the number of test by conducting tests on engines under the environment similar to real circumstances, and makes repetitive tests possible under the same condition. It also substitutes any dangerous tests resulting in damage to engines with testing real engines since it can incarnate extreme situation such as fault insertion testing which may be difficult to be conducted in a real physical test. Therefore, most of the engine manufacturers and controller manufacturers requisitely own and operate a test bench for EECU (Electric Engine Control Unit).

For a typical case, SIMsystem by ADI (Applied Dynamics International) of US as a platform, which enables tests in real-time basis and development of FADEC, is the most widely used HIL test platform in the world. Rolls-Royce co. had used SIMsystem for developing FADEC from the Tay-611 to the Trent 900 engine [1].

Prevas in Sweden had developed HIL simulator for the FEDEC test and verification of RM12 engine, and used NI's PXI hardware platform, which is PC-based industrial standard platform. The company also developed all the software of HIL simulator by using LabVIEW [2].

PI (Price Induction) company of France has

Received: March 25, 2014 Revised: June 19, 2014 Accepted: June 26, 2014
† Corresponding Author
Tel: +82-42-336-3480, E-mail: m.c.kang@ezgtc.com

developed WESTT CS/BV for simulation of multi-purpose engine performance and test of the turbo-fan engine developed under the name of EN380, and is selling the product for educational and R&D uses.

In South Korea, the project called "Development of EECU platform of gas turbine engine's FADEC for aircrafts" as a part of technology development for aerospace parts sponsored by the Ministry of Trade, Industry & Energy is being carried forward. This study is a part of the development of test bench and testing EECU performance that is to be developed as stated in the foregoing, and is to describe the composition and functions for the operating software of the test bench.

2. Test Bench for the Developing EECU Test

The purpose of the project (Development of EECU platform of gas turbine engine's FADEC for aircrafts) in progress is to develop EECU platform, which is the core technology for securing fundamental technology of FADEC development. Along with the foregoing, the development of test bench for testing developed EECU is also in progress.

The EECU under development is composed of H/W and S/W where H/W includes 6 kinds of circuit boards, electrical wire devices and housing, all of which conduct signal processing. S/W is composed of M/W (Middle Ware) and A/S (Application Software). M/W processes input and output signals of sensors whereas A/S conducts engine control, channel management and health monitoring for each channel.

For verifying the EECU's functions and performances, the test bench basically should be able to conduct the followings.

- Test of engine control logic
- Test of EECU operation and safety
- Test for virtual malfunction, injection and reliability
- Test for diagnosis algorithm
- Communication test for dual channels
- Simulation for engine's normal/transient operation
- Securing test data and management

The verification for integration of EECU by the test bench is conducted in a manner that the input signal from the cockpit through Throttle Lever (PLA) and communication data bus to operate engine and air data is delivered to EECU, then the virtual engine is operated by receiving the engine control signal from EECU.

For the foregoing, the test bench under development is composed of S/W including operation and management system for test bench, cockpit simulator, real-time engine simulator, SILS (Software-In-the Loop Simulation) & DB (Data Base) system, and harness, and other hardware. In addition, the platform considering the channel expandability is reflected for practical use of other similar EECU tests.

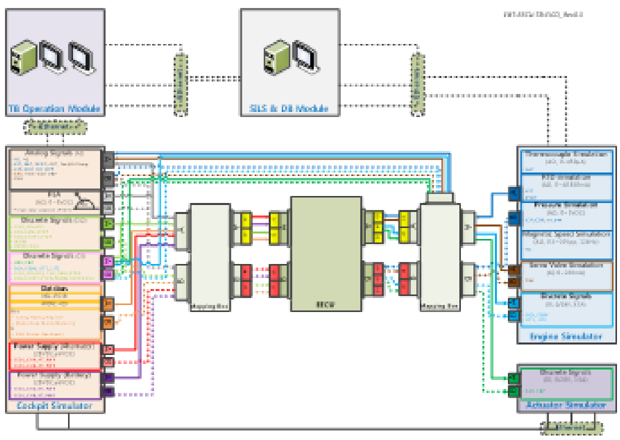

Fig. 1 Test Bench System Interface Arrangement

3. Test Bench S/W

The operation program for the test bench is developed by using the commercial tool, LabView, and the interface with SILS which developed by

Matlab/Simulink and H/W signal can be composed by this LabView.

The operation program for the test bench is composed of 3 modules as show in the Fig. 2.

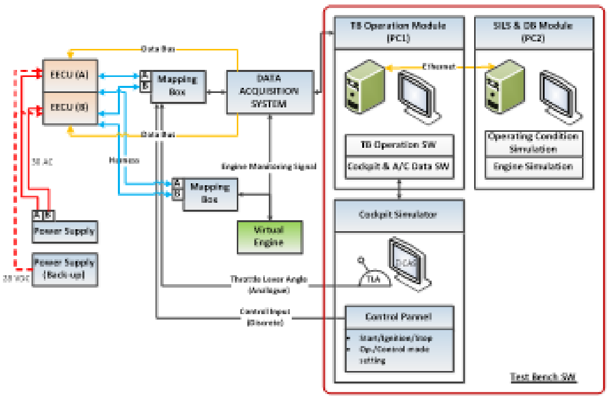

Fig. 2 Test bench s/w block diagram

4. TB Operation Module

The TB operation module for the test bench as shown in Fig. 2 is composed of Test Bench Operation S/W, Cockpit and Aircraft Data S/W, and conducts operation of test bench, securing and processing operation data, and self-checking for the test bench.

4.1. Tiest Bench Operation S/W

The main function of test bench operation S/W is fundamentally to operate the test bench. In order to operate the test bench, the operation and test mode should be set in advance.

The operation of test bench can be achieved by manual operation of an operator or conducting a test based on operation scenario developed by the system. In addition, it can conduct testing operation of EECU when malfunctioning by simulating the failure of signal to EECU.

Along with the foregoing main functions, it acquires and processes the data from operation of the test bench, and manages them by filtering

4.2. Cockpit & Aircraft Data S/W

The flight condition data provided by the aircraft system is delivered to EECU through simulation based on the flight and operation condition developed by the system. The data from the Ambient Data System including atmosphere temperature and pressure, altitude, and flight speed, and the data from the aircraft system including WOW signal are created. Along with the foregoing, bench tests can be conducted by setting as normal operation, limit operation and signal failure condition.

It includes a model for the condition as simulated as signal failure, and the applied types of signal failure are shown as Fig. 3.

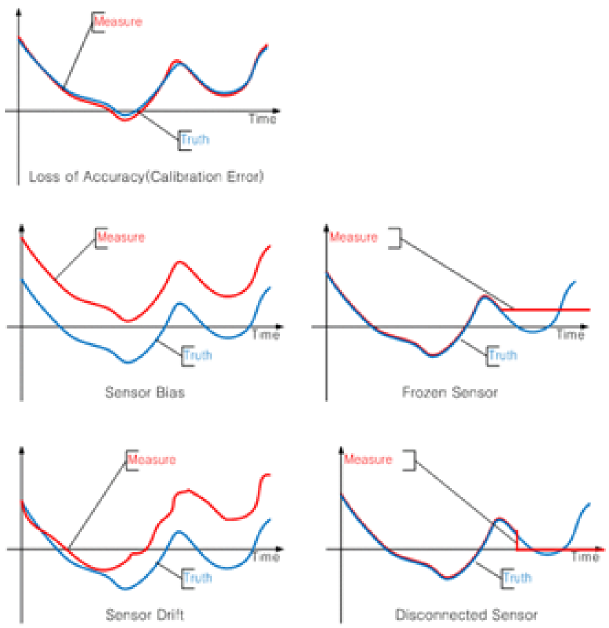

Fig. 3 Type of sensor signal failure

5. Cockpit Simulator

The cockpit simulator simulates and provides control input signals which are from the cockpit in aircraft by a pilot, and displays real-time status of engine.

The cockpit simulator in composed of throttle panel, control panel, and status display panel (Engine Indicating & Crew Alerting System; EICAS) as shown in the Fig. 4.

The throttle panel is composed of throttle lever and engine operation switch, and delivers various control signals including power setting command (PLA) by a pilot, start/ignition, stop, setting operation mode and control mode, to EECU. The basic composition of control panel and its descriptions are shown as below.

- Throttle mode setting: Take-Off, Climb, Cruise, Max. Continuous, and etc
- Monitoring mode: Engine monitoring, failure monitoring and recording
- Event Switch: Operation of engine condition and fault reporting
- Start and ignition switch
- Engine stop (Fuel Shut-off)

The engine status display (EICAS) conducts displaying the status of engine through data communication bus delivered from EECU.

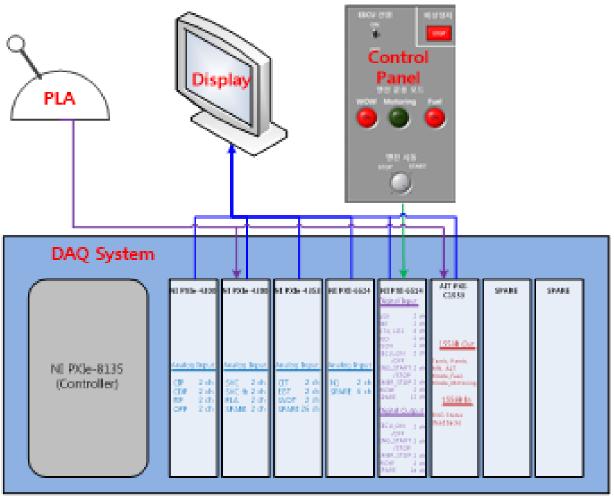

Fig. 4 Test bench cockpit simulator architecture

The composition of interface between the cockpit and EECU is shown as the Fig. 5.

6. SILS & DB Module

The SILS provides operating environment for engine and EECU model by S/W simulation based on PC environment. For this, the design of SILS model is conducted and composed with the requirements of EECU's interface. It is developed by using Matlab/Simulink under PC environment.

The SILS is independently operated apart from the operation program of test bench, and is composed of flight condition model, cockpit interface model, aircraft data model, engine model, actuator model, and EECU model as shown in the Fig. 6. Among them, the flight condition model, cockpit interface model and aircraft data model have the same concept as applied to the test bench operation module.

The DB (Data Base) system acquires and store the data created during the operation of EECU and other test bench, and provides signal information regarding the air data and engine control.

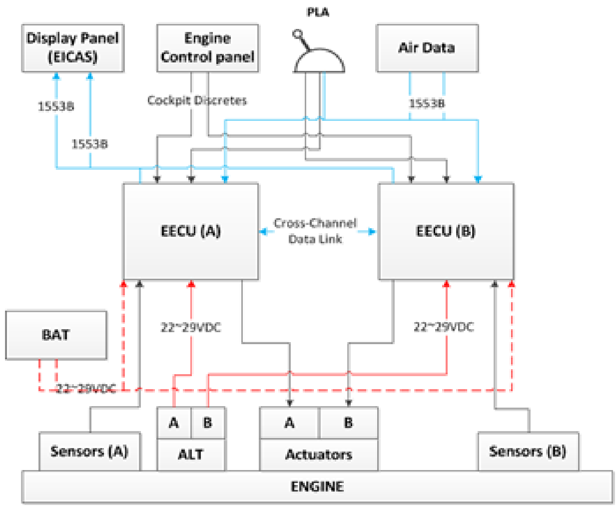

Fig. 5 Cockpit interface

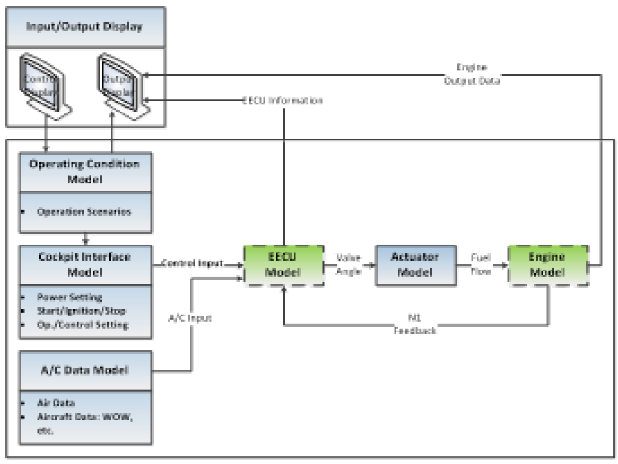

Fig. 6 SILS Block Diagram

6.1. Engine Model

The thermodynamic model and linear piece-wised model are used in the engine model. The thermodynamic model is applied to SILS, and used for simulation of normal/transient operation and creation of test cases.

The linear piece-wised model, which is developed by using Simulink, is embedded in the real-time simulator as a virtual engine to input/output data and physical signals as same as EECU's real target engine. It also independently can monitor the status of this virtual engine (engine model, monitoring variables for measurement of virtual engine, data comparison).

The real-time engine simulator receives analogue signals of EECU as inputs of real-time engine model to operate the virtual engine where the status of engine as analogue signals converted from virtual sensor is delivered to ECCU.

The real-time engine simulator is composed by the xPC Target Turnkey H/W of MathWorks, and its composition is shown as Fig. 7.

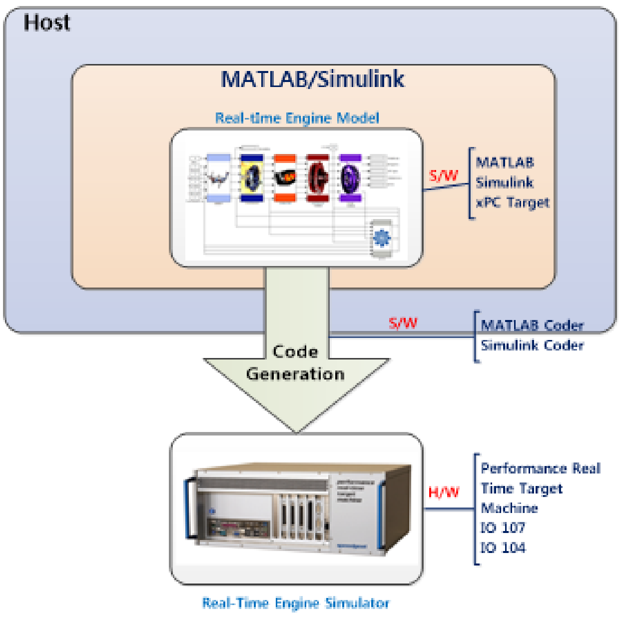

Fig. 7 Embedded real-time engine model for virtual engine simulator

6.2. Actuator Model

The actuator model includes fuel control model in servo valve type. The main purpose of the servo valve is to provide exact amount of fuel to its subordinate valves or actuator. The servo valve, which is generally used in engine control, can be classified into torque motor type and jet pipe type. Both types are electronic hydrodynamic devices. Their operation manners are different but their dynamic models are similar. Under the normal operation condition, the motor is modelled as the secondary system whereas orifice is modelled as servo gain in this model. The basic design concept of the servo valve model is show as the Fig. 8. [3]

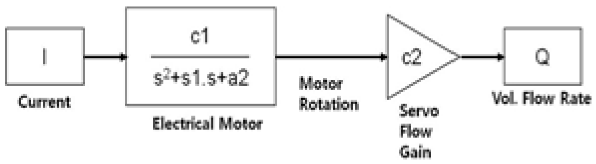

Fig. 8 Servo valve model

7. Conclusion

In this study, the development concept and composition of S/W for the test bench of EECU under development are described.

The major purpose of test bench is to establish test environment, which is materialized as per the standards of certification, for EECU and to develop it with fulfilling the requirements of certification.

With using the test bench under development, verifying logic of EECU, SW test, SW integration test, and SW-HW integration test are to be conducted.

Acknowledgement

This study could be conducted by the support from the Korea Aerospace Technology Research Association (Study #: 10043602, called "Development of EECU platform of gas turbine engine's FADEC for aircrafts”) as a part of the technology development for aerospace parts program sponsored by the Ministry of Trade, Industry & Energy. So it is greatly appreciated. Acknowledgement. Acknowledgement.

References

[1] Applied Dynamics International, 2004, “Jet Engine HIL Simulation for Electronic Control System Testing”

[2] Prevas, 2009, "Hardware-in-the-loop Test Rig for Jet ECU"

[3] Link C. Jaw and Jack D. Mattingly, 2009, "Aircraft Engine Controls Design, System Analysis, and Health Monitoring", AIAA Education Series

Authors

Myoungcheol Kang
Graduated with a BSc and MSc in Aerospace Engineering from the Chosun University, Rep. of Korea.
He was appointed to Research Engineer in EGT Co., Ltd. since 2007

Seonghee Kho
Graduated with a BSc and MSc in Aerospace Engineering from the Chosun University, Rep. of Korea.
He was appointed to Research Engineer in EGT Co., Ltd. since 2006

Jayoung Ki
Graduated with a BSc and MSc in Aerospace Engineering, PhD in Mechanical Engineering from the Chosun University, Rep. of Korea.
She was appointed to CEO in EGT Co., Ltd. since 2006