HEWLETT® PACKARD

Jet Engine Testing

Application Note 1270-10

Applications
Commercial Jet Engines
Business Jet Engines
Military Jet Engines
Auxiliary Power Units

Departments
Research and Development
Engine Test Consultants

Description

A jet engine is a complex machine, capable of producing thousands of pounds of thrust at altitudes from sea level to 50,000 feet. Some engines are designed for maximum thrust and response while others are designed for fuel economy. Many physical parameters must be measured to optimize engine design.

Problem

Many engine parameters must be measured at relatively high speeds to accurately characterize engine performance.

Solution

Using a Hewlett Packard VXI Computer Controlled Data Acquisition System, various engine operation parameters can be measured and correlated to analyze a new engine design. The data acquisition system is used to perform switching functions between instruments and measurements. Counters, oscilloscopes, and spectrum analyzers are also used to complete the analysis. The results of these measurements can be displayed in real time depending on the implementation of the software. Test programs can be made to plot different parameters against each other. With computer tabulated results, it is possible to detect design flaws and improve thrust or fuel economy on the engines.

Implementation

Temperature

Thermocouples with signal conditioning are often used to monitor temperatures at various, points inside and outside the engine. Since thrust is fundamentally dependent on temperature differentials, engine temperatures are used to measure the effectiveness of engine design.

Instrumentation: Integrating DVM, Relay Multiplexer with Thermocouple Compensation

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Air Pressure

The efficiency of the jet engine is, in part, determined by air pressures at various stages inside the engine. Engine pressure ratio (EPR) is a parameter used in engine efficiency thrust calculations. Transducers measure pressure at points in the intake, compressor and turbines. Transducer output is usually a 4-20 mA current loop.

Instrumentation: Integrating DVM, Relay Multiplexer

Fuel Flow

Fuel efficiency is calculated by measuring fuel flow. Flow transducers can output either a set of pulses, a voltage (0-10 Vdc) or a current (4-20 mA) that can be acquired by the system. For high-speed measurements, the transducers output voltages are scanned by FET multiplexers, acquired by high-speed DVMs and stored on a computer disc.

Instrumentation: Counter, High-Speed DVM, FET Multiplexer

Vibration

At high speeds, small vibrations can cause a turbine engine to self-destruct. Digital signal analyzers (spectrum analyzers) are used to measure the vibration signature of rotating engine parts. Real-time FFTs allow the user to instantly see the vibration signatures produced by the engine while under test.

Instrumentation: Spectrum Analyzer

Emissions

Carbon monoxide, carbon dioxide, smoke and various other gases are byproducts of the engine combustion process. The concentration of these gases are measured using transducers. These transducers output millivolt signals that can be sensed, linearized and correlated with other engine test parameters by the data acquisition system. Environmental regulations continue to increase the importance of these measurements.

Instrumentation: Integrating DVM, FET Multiplexer

Speed

The rotational speed of the jet turbine is another parameter monitored in an engine test. Speed transducers usually output pulses with a frequency proportional to the speed of rotation. A counter is used to measure the frequency. Speeds of up to 30,000 rpm are easily handled in this manner.

Instrumentation: Counter

Throttle Control

The throttle is a mechanical device that gradually increases the fuel flow to increase turbine speed and ultimately, thrust. To move the throttle in a measurable pattern, stepper motors are used to precisely position the throttle.

Instrumentation: Stepper Motor Controller

Key System Features

- Thermocouple Linearization
- Emission Transducer Linearization
- Switching of Transducer Signals between Instruments

Typical System Configuration

Data Acquisition System	Qty
13 Slot Mainframe	1-3
High-Speed DVM	2-5
FET Multiplexer Channel	60-300
Integrating DVM	1-5
Relay Multiplexer Channels	40-200
Counter Channels	5-50
Stepper Motor Controller	1-5

Computer/Software

- HP Series 700 Computer Workstation
- VXI MXI Module
- Keyboard, Monitor and Mouse
- Disc Drive, Printer and Plotter
- MXI Interface
- Software - HP-UX and C Language Development Environment

Other Equipment

- Spectrum Analyzer

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