System Monitoring and Diagnostics

The Next Generation of System Monitoring

Significant Projects:
- C-141 Fuel Pump Condition Monitoring System.
- Commercial Aircraft Integrated Drive Generator.
- Navy P-3C Generator.
- Gaseous Diffusion Plant Compressors.
- Enclosed Space Detection System.

Sponsors:
- U.S. Navy.
- U.S. Army.

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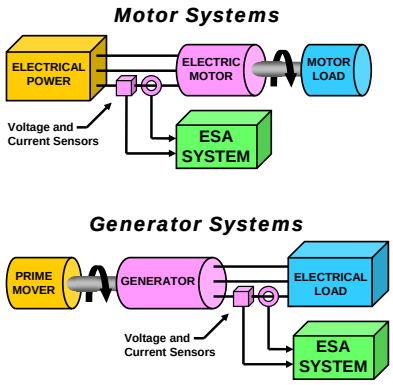
Dynamic Systems Analysis and Simulation (DSAS) Group members have extensive experience developing novel applications for system monitoring and diagnostics. The tools used to develop these applications include Electrical Signature Analysis (ESA), time and frequency domain analysis, nonlinear time series analysis, wavelet analysis, and model-based diagnostics.

Electrical Signature Analysis

In ESA, a motor (or generator) of the system under test is used to provide diagnostic signals, much like a built-in transducer. Variations in electric current or voltage are analyzed and related to the electrical and mechanical condition of the tested system. ESA applications have included motor-operated valves, pumps, compressors, and generators used in a large variety of applications and industries.



Electrical Signature Analysis (ESA).

Advantages of ESA over conventional vibration monitoring include:

- Transducers do not need to be added to the system—ESA can be applied quickly and inexpensively even to existing systems.
- Measurements can be made anywhere along the electrical line—ideal for inaccessible systems or systems in harsh environments.
- Defects can be detected throughout an entire system with a single current or voltage probe—sensor location is not important.

Model-Based Diagnostics

Traditional diagnostic methods have proven the ability to detect changes occurring in a monitored system. Model-based diagnostics use system models to relate changes in measured quantities to their source. A system model relates system parameters, such as stiffness or damping values, to measureable descriptors, such as natural frequencies. A neural network or optimization software is used to effectively "invert" the system model; the inverted model relates measured descriptors to system parameters. Model-based diagnostics trend the system parameters estimated from the inverse model over time. Changes in these parameters indicate the magnitude and location of system degradation.

Map Error Time Series Diagnostics

Map error diagnostics use nonlinear time series analysis techniques to construct a one-step prediction map that models the behavior of the monitored system. Measured signals are compared against predicted values; the difference between the measured signals and predicted values is the map error. The map error forms a time series in which deviations from expected behavior are greatly amplified while time and frequency information are preserved. This amplification allows degradation to be detected using map error long before it can be detected in the original time series.