

Fault Tolerance Control of Electrical-Mechanical Systems

As technology develops, more and more automated systems are implemented for everyday use. Along with these technology advancements, more complicated problems which are associated with failures of such system arise as well. Unlike traditional systems, these automated systems generally are more complicated, involve more components, do not require human monitoring, and operate in more critical conditions such as in nuclear plants and on airplanes. A system that solves the stated problems is called a Fault-Tolerant system. Properly designed Fault-Tolerance systems will keep the system to operate within normal range in the events of unanticipated failures, without shutting down completely or causing catastrophic consequences to the system and its surroundings. The inverted-pendulum system is investigated using computer-based simulations to engage the technical knowledge acquired about Fault-Tolerance systems with actual practice.

Four of the major characteristics of the FTC include redundancy, job priority, level of FTC, and time-criticality. Concepts of these four characteristics are explored and examples are used for better understanding of applications of FTC in practice.

Redundancy refers to the duplication of key components for system backup. Two common types of redundancy are hardware and software redundancy. For Fault Tolerance Control, objectives are prioritized, which is the concept of the so-called job priority in FTC. In the event of a failure, depending on the level of the failure objectives with lower priorities are discarded to ensure the fulfillment of top priorities. The most critical characteristic is the level of FTC, which means is that the severity of faults triggers different level of responses. In other words, the level of response performed is proportional to the severity of associated failures in FTC systems. Associated to the level of FTC there is another characteristic called time-criticality. In response to the faults that occurred, sometimes control mechanism need to be implemented immediately if the fault is a failure or an emergency, while other times faults can be compensated using the redundancy mechanism and be resolved until the next scheduled maintenance.

Inverted-pendulum system is a classical example of FTC systems. In an inverted-pendulum system, a mass is balanced on the tip of a pendulum while the pivot point is fixed on a moving cart, thus the name "inverted-pendulum". To demonstrate the concept of FTC, different forces are applied to the cart while the cart tries to keep the mass balanced.

Motivation of Fault-Tolerance designs is to increase safety levels of automated, especially unmonitored, systems. However, there are some shortcomings to the present-day FTC designs. Testing of FTC backup schemes poses a major technical difficulty as current system needs to be shut down to verify the functionality of FTC backup schemes. Interfacing among components of a system also affect judgment of FTC design, since sometimes certain failures are not due to one component, but outputs of other components. More breakthroughs in design of Fault Tolerance Control designs will sure perfect the concept of FTC, thus creating a safer environment.