THE USE OF TELEMETRY IN AN ELECTROMAGNETIC TEST ENVIRONMENT

William J. Papich
US Army Redstone Technical Test Center

ABSTRACT

The U.S. Army Redstone Technical Test Center (RTTC) uses telemetry as a vital part of its data acquisition and analysis for electromagnetic environmental effects developmental testing of U.S. Army weapon systems. Testing in an electromagnetic environment poses several unique challenges. These challenges have resulted in the development of highly customized telemetry and data acquisition systems. This paper discusses the design and integration of past and current telemetry needs to incorporate real-time or near real-time simulations or scene generations into the testing process.

KEY WORDS

Frequency Modulation (FM), Hardware-in-the-Loop (HWIL), Radio Frequency (RF), Data Acquisition, Pulse Code Modulation (PCM), Electromagnetic

INTRODUCTION

 U.S. Army weapon systems are tested extensively to ensure they function safely and properly. There are several environmental tests that are performed during the developmental cycle. Telemetry is used extensively in this testing. However, telemetry used in an electromagnetic environment requires special design and integration. Techniques and applications standard to most telemetry designs are not applicable. The U.S. Army Redstone Technical Test Center (RTTC) has developed customized telemetry to meet a weapon system's individual requirements. These requirements range from physical size constraints to faster data rates. It is important to be adaptable to changing technology. Current electromagnetic testing is limited to a "static" or open loop functional test. An initiative has begun to close the loop, similar to Hardware-in-the-Loop (HWIL) testing, to obtain true weapon system performance characteristics. Meanwhile, the integration of simulation techniques into developmental testing is placing more requirements on the telemetry. Faster data rates, latency, and video are just a few areas that need to be explored before these requirements can be met.

BACKGROUND

Testing in an electromagnetic environment differs greatly from other test environments. The electromagnetic test environment is very extreme. Average electric fields (E-Fields) can be produced with ranges from 10 to 200 V/m. In some instances for radar applications, peak E-Fields can exceed 1000 V/m. The telemetry is not only required to operate in these environments, but it must not produce additional coupling paths for the electromagnetic energy to induce problems, either for the weapon system or the telemetry. Therefore, the design and integration of the telemetry is very important for a successful electromagnetic test program.

Several factors are involved in telemetry design and integration. Telemetry isolation, physical connections, power requirements, data links, and data acquisition are some of the major areas of concern. To avoid changing the electrical characteristics of the system, the telemetry must be isolated from the system. However, this task is difficult and sometimes impossible. Therefore, it is necessary to achieve the maximum isolation possible in the telemetry integration. Physical connections within the weapon system are kept to a minimum, especially the length. All external connections to the weapon system are required to be nonconductive. Telemetry power is a vital part of the process. Typical electromagnetic tests can last up to 16 weeks. Therefore, a reliable power source is required to power the telemetry and sometimes the weapon system. The power source must be internal to the system since no external physical connections are permitted. Rechargeable nickel cadmium (NICAD) batteries provide an excellent power source. However, NICAD batteries require recharging and weapon system size constraints limit the number and type of batteries that can be used. To resolve this problem RTTC developed an air turbine power supply. The air turbine is powered by an air compressor with a nonconductive air hose and is capable of producing multiple voltages and continuous currents in excess of 6 amps. The air turbine provides a very unique test capability.

Another unique capability is the telemetry data link and data acquisition software. When performing an electromagnetic test, it is necessary to obtain data either real-time or near real-time. Post processing of test data results in test delays. Since a direct data link is a conductive external connection that would induce additional problems and since a radio frequency (RF) data link is not applicable due to the extreme electromagnetic test environment; a fiber optic data link is the only viable solution. The fiber optic data link provides a nonconductive means to transmit data to and from the data acquisition station. Special in-house developed data acquisition software is used and tailored to meet a weapon system's individual requirements.

EM TELEMETRY

In recent years there have been several milestone accomplishments in telemetry designs and data acquisition processes since the early use of standard Voltage Controlled Oscillators (VCOs), discriminators, and analog strip chart recorders. Some of the first upgrades consisted of the introduction of a 5-volt VCO, a Hewlett Packard HP-1000 series computer, and the implementation of a printed circuit board (PCB) CAD system.

The low voltage VCO replaced the standard 28-volt VCO. This was a major reduction in the power requirements. The HP-1000 computer was a major improvement in test automation, data acquisition, and data reduction. PCB designs were produced via the CAD system. This allowed designs to be verified through simulations prior to fabrication. These three upgrades were considered milestones in productivity and reliability. However, software developed on the HP-1000 was limited to specific electromagnetic tests. It was clear that electromagnetic testing of future weapon systems would require more sophisticated data acquisition and reduction software. With the advent of personal computers (PCs), an effort was initiated to develop a PC based software program that could easily be applied to all aspects of electromagnetic testing; creating a system where a user could easily develop a software test program utilizing a database of hardware drivers. Hence, *AutoTest* was developed. *AutoTest* provided capabilities beyond any commercially available software package. *AutoTest* completely automated the data acquisition and reduction process. It provided the computer operator a graphical user interface (GUI) to evaluate system performance parameters near real-time. Other tools were added to *AutoTest*'s capability such as multi-channel signal processing, networking, and image processing. This software package was a milestone in the test process and is still in use today.

Another milestone was the development of the air turbine. As mentioned previously, the air turbine is an extraordinary way to power telemetry on demand for unlimited use with a nonconductive connection. In addition, the air turbine is used to power weapon systems. For example, in a missile system the air turbine replaces the missile's thermal battery. It provides the same characteristics of the thermal battery, except, unlike a thermal battery, the air turbine can be used again and again.. These characteristics make the air turbine an ideal power source for electromagnetic testing.

To upgrade from Frequency Modulation (FM) systems, several Pulse Code Modulation (PCM) systems were purchased. It included PCM encoding hardware and decom systems. The encoding hardware was integrated into the telemetry design to meet testing requirements. With increased channel capacity and more reliability, PCM systems were a significant improvement over FM systems. These systems have been replaced with portable PC based decom systems. Current PCM systems provide a full data analysis

capability. In addition, development software allows the user to easily customize software to the weapon system's requirements.

APPLICATIONS

Current applications continue to address safety and performance data while the weapon system is being exposed to an electromagnetic environment. Telemetry formats ranging from MIL-STD-1553, RS-485, RS-422, and complex and multiple PCM streams are experienced on a continual basis. The conversion of these telemetry formats to fiber optics has been accomplished. However, adjusting for the increase in the data rates is an ongoing process. Upgrading software is another ongoing process. With each new weapon system, a new data acquisition program is developed. Recently the most emphasis has been put on developing a portable instrumentation capability. Requests to make our instrumentation services available to support ongoing remote tests have created the need for portable instrumentation. The use of portable PCs, single channel FM ISA boards, PCMCIA cards, and multi-purpose PCM boards are being explored to meet these requirements.

FUTURE APPLICATIONS

Today's Army is moving to incorporate modeling and simulation techniques into everyday developmental testing. This will be a significant challenge, especially in an electromagnetic environment. Past and current electromagnetic testing portray weapon system performance in a "static" and "discrete" environment. The lack and expense of dynamic movement, realistic targets and the overall cost of the entire developmental test program drives certain factors of the program. It is important that the system performs for the soldier as it was designed. Therefore, to analyze its performance, it is necessary to subject the weapon system to a realistic scenario. Here are a few areas that are being considered for future electromagnetic effects testing to meet these requirements:

- Implementation of Real-time Simulations
- Scene Generation (IR and MMW) Capability
- Faster Data Rates Via Fiber Optics
- Latency Problems
- HWIL Techniques
- Electromagnetic Modeling and Simulation

CONCLUSION

Telemetry provides the ability to determine if the weapon system meets its design specifications. Telemetry has and will continue to be an integral part of the process used to conduct electromagnetic testing. The improvement of design and integration techniques,

telemetry hardware and software is a continuous process, especially with today's rapid technology growth. RTTC has accepted the challenge and is leading electromagnetic testing to the future.