

FISO offers unique instrumentation for EED testing



APPLICATION NOTE



TODAY'S TECHNOLOGICAL ADVANCES IN TELECOMMUNICATIONS HAVE YIELDED A NUMBER OF MORE AND MORE POWERFUL RADAR AND TRANSMITTER-RECEIVER SYSTEMS THAT EMANATE ELECTROMAGNETIC (EM) ENERGY AT HIGH LEVELS.

Parallel to this development, is the trend to use more sensitive, low power electronic circuits in the design of electro-explosive devices (EEDs). EEDs are electrically initiated devices (EIDs) having an explosive or pyrotechnic output and they are activated by an electro-explosive initiator. EEDs are used in many industrial and civil applications such as fire extinguishers and automobile air bags, but the ones we shall discuss in this article are the ones related to military uses such as in aircraft and weapons systems.

In military systems, EIDs perform a variety of functions, such as initiating rocket motors, arming and detonating warheads, and ejecting chaff and flares. By design, these devices can be susceptible to electromagnetic interference emanating mainly from the high-level EM energy communication devices that can accidentally activate the device and cause an unexpected detonation.

The main problem with EEDs is what may result from the adverse interactions between the EME and the electrical initiators or initiating systems contained within ordnance systems. These hazards are referred to as HERO or Hazards of Electromagnetic Radiation to Ordnance and tests are required to measure the amount of energy developed in the EED circuits in order to insure against spontaneous and unwanted detonation while exercising the device's electrical system and/or operating strong electrical fields.

The US Department of Defense (DoD) has set forth in its reference document MIL-HDBK-240 all the information that is necessary to know to carry out HERO testing on EEDs, from the type of equipment to use, to the test procedure and reporting practices.



Test Approach

The general approach for HERO testing is to expose inert, instrumented ordnance to a controlled test EME and to monitor each EID contained within the ordnance for a possible response. For most EIDs, the response is quantified in terms of the magnitude of RF current induced into the heating element, or bridgewire, of the device.

Instrumentation systems used in DoD HERO programs measure the temperature rise in the bridgewire of an EID from which the equivalent induced RF current may be inferred. The important parameter is not the amplitude of the induced RF current, but rather the effect of the current, which is to cause a rise in the temperature of the bridgewire. However, it has become the accepted practice for HERO testing to quantify the EID response in terms of current rather than temperature. This equivalent dc current is used as a convenient point of comparison to the EID's statistical firing data that are usually given in terms of current.

Recommended Test System

EID instrumentation is unique for HERO testing. It appears to be rather simplistic to simply detect and monitor RF-induced responses of EIDs contained in an ordnance system. Yet, because HERO testing is complex and dynamic in nature, the instrumentation is also complex and very challenging. A typical HERO instrumentation system, as described in the military handbook, consists of four basic units:

- A sensor to detect an RF-induced response.
- A transmission line to carry the sensor data to a receiver or readout device.
- A device to translate sensor data into desirable units of measurement.
- A means of recording the data into a permanent record.

In essence, the required instrumentation characteristics are as follows:

- The sensor/transducer should be capable of detecting small changes in temperature in a device that has a small mass and, therefore, very little thermal energy associated with its temperature.
- The instrumentation system, that is, sensor/transducer, monitoring, and recording devices, should be capable of detecting responses to short duration pulses or stimuli.
- The sensor/transducer should not alter the firing and EM characteristics.
- The instrumentation system should not alter the EM characteristics of the ordnance system under test.
- The instrumentation system should not be adversely impacted or altered by the EME.
- The instrumentation system should be capable of operating for the duration of the test.
- The instrumentation package must be rugged, compact, and relatively simple to operate.

However, the most important factor concerning the instrumentation is that it must be sensitive enough to establish the required pass/fail margin when the system is exposed to its expected operational EME.

The instrumentation system should not be adversely affected by the EME. An all fiber-optic based system from sensor to receiver/recorder such as the Veloce 100 is the preferred instrumentation method of ordnance for HERO testing.

Test Sensors

There are a variety of sensors and transducers used to detect and measure ohmic heating of bridge wire-type EIDs. However, optical, sensor-based instrumentation systems are preferred over conductive-type sensor instrumentation systems because the potential impact on the ordnance system's RF characteristics is eliminated by the use of non-conductive instrumentation leads.

Some sensors are attached to or are in direct contact with, the EID's bridgewire. Others are positioned near the bridgewire (for example, within 0.003 inches). Non-conductive sensors (optical-based) can be placed in direct contact with or be attached to the bridgewire without altering its inherent electrical and EM characteristics. In addition, the position of the sensor/bridgewire is more stable and is less likely to change under environmental stress. The conductive-type sensors are not normally attached to, or in contact with, the bridgewire. Special care must be taken during the sensor installation process to ensure that the conductive sensor is correctly positioned and that it is secured in place so that its position does not change under environmental stress.

The basic steps for instrumenting ordnance for HERO tests are to minimize both the disturbance to the EM energy created by the instrumentation package and the coupling of the RF energy to the data channels. The instrumentation package should be small and internal to the ordnance item under test. Optical telemetry techniques may be used to reduce coupling of RF energy into the signal leads. Extreme care must be exercised to ensure that the instrumentation provides an accurate measurement of the voltage, current, or other response without significantly changing the test results. Instrumentation methods involving fiber-optic sensors and cables are used, almost exclusively, to achieve accurate, unperturbed measurements.

Safe EED Testing by FISO

The FOT-HERO sensor and the VELOCE-100 signal conditioner have been specifically developed for Hazardous Electromagnetic Radiation (HERO) testing of electrical shielding and electromagnetic compatibility (EMC). The fiber optic temperature sensor can be mounted in the EED, is immune to EMI, operates in real time, has a fast response time and is extremely sensitive.

With its tiny size of 150 microns and its low thermal mass, the thermal transfer from the source to the FOT-HERO sensor is almost instantaneous.

Since the FOT-HERO sensor is based in fiber-optics technology, it is inherently EME inert.

The FOT-HERO sensor provides, by design, an extremely fast response time, better than 275 milliseconds (defined as the rise time from 10% to 90% of the output, based on MK1 squib). Independently of the squib, the sensor response time is better than 1 millisecond. Its sensitivity is very high, also by design. Depending on the application, the squib and the test conditions, sensitivity could be of 3 mA and better.

The Veloce-100 system combined with the FOT-HERO sensor offers the unique reference instrumentation for EED safety testing. The system enables real time monitoring of EEDs while these devices are bombarded by electromagnetic fields. The FOT-HERO sensor is available bare, ready for field installation, or already mounted on a squib.

The principle of the Veloce 100 system is based on a Fabry-Perot interferometer. The signal conditioner contains a light source and a detector. For each slide-in module, the detector and light source are internally combined on one fiber optic line by a coupler and routed to the conditioner front plate, where fiber optic sensor is connected using a highly stable ST type fiber optic connector. The use of an extension cable is also possible. The system can reach as high as 200 kHz in sampling rate and is capable of averaging results, as required by the tests.

Sample Application

A typical application for the Veloce 100 and the FOT-HERO sensor is determining the optimum distance between two army tanks and a decoy launcher so as not to cause any interference between them that may accidentally activate any EID.

Thanks to the system, the army was able to determine that the minimum distance allowable was far closer than the currently established restriction.

The army runs tactical evaluation (Tac Eval) maneuvers that require army vehicles to operate in close proximity to where decoy launchers are loaded and unloaded from helicopters. Decoy launchers employ either CCU-41B (chaff activator) or CCU-136A (flare activator) cartridges. Previous lab testing had revealed some susceptibilities in the cartridges so a restriction in distance of 50 meters for any VHF radio was in place. This restriction would have considerably hampered the Tac Eval. Therefore, QETE was called in to see if the restrictions could be eased.

Utilizing FISO equipment, the cartridges were instrumented and the appropriate chaff and flares modified to re-create the actual installation as close as possible.

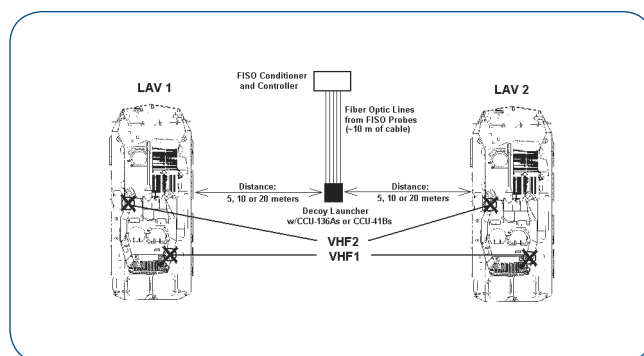
Test Setup

The test consisted on tuning in specific frequencies at a given power and distance. If a detonation occurred, the distance would be increased until a safe margin was attained.

Four instrumented cartridges of each type were inserted into the decoy launcher with its flares/chaff and vehicles were placed on either side of the launcher with a separation distance (launcher to vehicle) of 5, 10 or 20 meters. A total of 50 test runs were made, 25 for each cartridge/decoy combination.

The series of test Frequencies (in MHz) employed was:

- | | | | |
|---------|---------|---------|---------|
| 1) 33.2 | 3) 35.0 | 5) 41.1 | 7) 44.6 |
| 2) 34.9 | 4) 39.8 | 6) 42.4 | 8) 45.7 |



Measurement Method

For each test, the current was measured and recorded for a full 20 seconds. The transmitter was not activated until the 5-second mark to give an indicator if any current change on the bridge wire occurred (even minor – down to about 8 mA).

Conclusions

After executing the series of tests at 5 meters from the launcher without recording any significant disturbances, it was deemed unnecessary to proceed with the test at longer distances. It was also determined that little to no risk exists with the radios and frequencies tested, as long as the radios used in the TACEVAL operate in a similar frequency range and are not of significantly greater power.

The Veloce 100 system helped in specifying that if VHF frequencies are below 50 MHz and radios are not of significantly greater power output, reduction of operational restriction distances from 50 m to 5 m should be acceptable.

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