HEMP/IEMI Signal Filter Design and Confirmation of Performance

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Abstract—This paper discusses the design standards used and the testing performed on facility signal filters for use in HEMP and IEMI protection. Such signal filters include filters for control wiring, telephone, fire detection, and even data. While the design and testing of signal filters for EMC is similar to that of filters for HEMP/IEMI there are other tests designed to confirm the performance of signal filters for HEMP/IEMI protection. We begin by noting the design and safety standards used for validation of HEMP/IEMI filters. We will then review various standards that can confirm a filter's attenuation to conducted and radiated threats. This includes a filter's insertion loss performance and its radiated shielding characteristics when attached to an RF shield. A discussion on how Pulsed Current Injection (PCI) testing is done to confirm HEMP performance will follow and a brief statement on IEMI performance testing.

I. DESIGN AND SAFETY STANDARDS

A. Design and Test Parameters

In the United States, the de facto standard for guiding the design of signal filters is found in MIL-PRF-15733 as it provides the basic performance standards to evaluate filters. Everything from how much voltage can the filter withstand to the pull force that terminals can withstand. There are special considerations for signal filters for their design into HEMP protected areas. This has to do with the expected HEMP performance and the bandpass of the filter.

B. Safety Testing

Signal filters should be tested for safety, but the scope of standards for safety like UL1283, do not include signal filters. So one must turn to other standards such as IEC 60939 and MIL-PRF-15733 for guidance. Safety testing encompasses such items as DC Dielectric withstand (or Hi-Pot testing), Insulation Resistance, Temperature Rise, Capacitance Discharge (or Bleeder resistance check), and Life test. In some cases, these tests are to be performed as a validation of design and in other cases, the test is made on 100 % of manufactured products. For example, since Life tests are destructive tests, these are performed typically by a third party on production first articles. As long as production models do not deviate from the first article construction, the test results are considered valid for all subsequent articles produced of that model.

II. PERFORMANCE STANDARDS

A. Insertion Loss

To confirm a filter's conducted attenuation manufacturers typically use MIL-STD-220. It is worth noting that there are other commercial standards available such as CISPR 17 and IEEE 1560. These were written in order to address the perceived shortcomings of the MIL-STD-220 method. Insertion loss testing can be used to indirectly assess a filter's attenuation to conducted IEMI. While practical, it may not be accurate. RF Injection may be more accurate, but typically not practical or done at the factory. A typical test setup for Insertion Loss is shown in figure 1. The measurement of insertion loss is typically a production test.
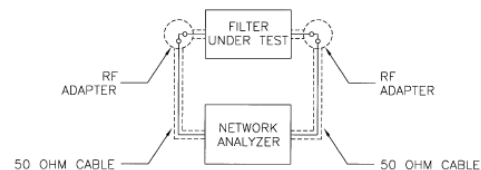

Figure 1. Typical test set up for Insertion Loss testing

B. PCI Testing

For confirmation of HEMP performance, we briefly examine the requirements for signal filters found in MIL-STD-188-125 and commercial standard IEC 6100-4-24. Some design challenges will be pointed out for data filters. The military standard is only concerned with HEMP and not with IEMI. Pulsed Current Injection testing is used to verify HEMP performance and signal filters should be tested for their response during a simulated HEMP event using a double exponential waveform as shown in figure 2. Most of these tests are done as a filter design verification or as an acceptance test in an installation, typically by a third party.
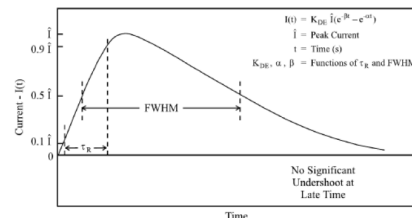

Figure 2. PCI testing waveform

C. Shielding Performance Testing

A shielding effectiveness test can be used to indirectly assess a filter's ability to reduce radiated HEMP/IEMI into a protected area. This test can be performed when the filter is attached to a shield and can be accomplished with well known standards such as MIL-STD-285 or IEEE 299. Other international standards such as IEC 61000-5-10 and IEC 61000-4-36 also provide methods for evaluating immunity to the IEMI threat.