MPE's filter design because of its good combination of reaction time – when mounted effectively – and energy handling characteristics, making it suitable for both the E1 and E2 pulse requirements.

Circuits were built and tested as it was initially thought that two stages of transient suppression would be needed to meet the difficult residual pulse current requirement of the MIL-STD. Different values of capacitance and inductance and different types of transient suppressor were tried in more than fifty different circuit configurations. Each time the current and voltage in each part of the circuit were monitored.

When testing the initial circuit, an injected 8/20µs pulse current of 2280A was reduced to a residual current, of 256A in the 2 ohm load resistor. Subsequently, by carefully adjusting the filter components, the second stage of transient suppression was eliminated, and the circuit was further improved and simplified, resulting in a 65A residual current for an injected pulse current of 2360A.

It is not easy to read across the laboratory 8/20µs pulse test results to the MIL-STD E1 pulse because of the difference in energy content of the pulse, the non-linear behaviour of the filter inductors, saturation of inductor core material, and parasitic capacitance of the inductors. However, for the 8/20µs pulse, a significantly higher residual current than 10A was expected owing to the energy content of the pulse. What was not certain was what value of residual current for the 8/20µs waveform would relate to the 10A requirement when testing with the proper MIL-STD E1 waveform.

Because there is no filter insertion loss requirement within MIL-STD 188-125, a standard design was developed to be commensurate with the MIL-STD 188-125 shielding attenuation requirement of 20dB at 10kHz and 80dB from 10MHz to 1GHz.

After completing the filter designs and testing in the MPE laboratory, it was necessary to validate the designs by subjecting them to the correct MIL-STD pulses, described in MIL-STD 188-125 as Acceptance Testing. All three new designs were tested and proven to the correct MIL-STD E1 and E2 pulses at an independent test house, Jaxon Engineering & Maintenance in Colorado Springs, USA. They passed all the tests by a large safety margin. The most important parameter is the residual current, and even the standard circuit achieved a residual current of less than 1.5A with a 2.5kA injected pulse, compared with the specification requirement of less than 10A.

The residual currents are significantly better than those expected from a modified catalogue filter. The higher performance circuits gave even better pulse performance than the standard design, as well as offering a higher insertion loss.

Testing was conducted on filters of 16A current rating. Further tests were subsequently carried out on a range of filter designs with current ratings from 6A to 200A, all of which similarly passed the tests with flying colours.

In conclusion, the final MPE standard filter design, as shown on the right of Figure 1, proved to offer an extremely low residual pulse current performance, much better than would be expected from an adapted catalogue filter, and in a smaller and lighter package. The circuit design yielded additional benefits of lower leakage current and lower heat dissipation compared to normal catalogue EMI filters. Reduced size and weight allow easier installation and a more cost-effective solution for HEMP protection. EPD