

## Review of Electrical - Power Transformer Responses to Fast Transients

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Power transformers in the power grid are vulnerable to both man made and natural threats. This paper documents a literature search on the effects of fast electrical transients on power system transformers, for the purpose of estimating the effects of a high-altitude electromagnetic (HEMP) environment on transformers. In this study, data for both the HEMP signal attenuation and distortion as it propagates through the transformer, and for possible damage to the transformer has been found, and the measurement programs that developed these results are discussed. Unfortunately, only a limited number of results have been found, so the generalization of these measurements to a wide variety of different transformers is difficult. However, these results do provide some insight into transformer operation in an HEMP environment.

A previous study of high-altitude electromagnetic pulse (HEMP) effects on electrical power systems has concluded that power transformers can play an important role in determining the nature of the electrical surges that may be conducted into a facility [F. M. Tesche, and P. R. Barnes, "The HEMP Response of an Overhead Power Distribution Line", *IEEE Trans. Power Delivery*, Vol. 4, No. 3, July 1989]. While this report treated only the loading of the power distribution line by the transformer, there is evidence that the transformer will modify the HEMP surge that propagates through this circuit element, thereby modifying the response of load equipment. We need an understanding of how a fast transient surge induced on a power line will be modified by the transformer. If such a surge is not highly attenuated by the transformer, it may cause damage to more sensitive components within the system. The second issue is to understand if the transformer itself can be damaged by the surge. To understand these two issues, it is useful to examine and summarize existing data on the responses of power transformers to fast electrical surges. Over the past ten to fifteen years, some work on fast-pulse responses of transformers has been undertaken. Using the previously discussed test data for transformers subjected to HEMP surges, one can develop an understanding of the filtering of the surges, as well as the possible failure of the transformers.

Gilbert et al (Metatech report 321 available on the internet), in a pioneering effort on protection from HEMP E3 environments, have looked at temperature rise in transformer oil tanks. There are also issues with transporting large power transformers from point A to point B, where they may be needed.

This presentation serves to review the some of the available data and literature in this area, and to summarize what has been found about transformer responses to transient excitations.

