Power Electronics Field Test Facility (TPET)

Overview:

The Power Electronics Field Test Facility (TPET) is a unique test facility for field testing of power electronics that will be located at the TVA Roane Substation in Oak Ridge, Tennessee. The TPET will be jointly operated by ORNL and TVA and the substation where it will be constructed is located at the East Tennessee Technology Park (formerly the K-25 uranium enrichment plant), a DOE federal reservation. The facility is the fourth facility to be built as part of the National Transmission Technology Research Center (NTTRC). TPET's purpose is to accelerate the testing of power electronics and energy storage technology from laboratory development and testing through field testing with the goal of accelerating real world application. TPET will allow product refinement in a controlled substation that mimics real-world electrical environments under controlled conditions.

Description:

The Power Electronics Field Test Facility (TPET) is presently being designed; construction will start the later part of FY04 or earlier part of FY05. TPET is a unique facility that will provide a field test platform for power electronics and energy storage testing at TVA's 500kV Roane Substation located at Oak Ridge National Laboratory in Oak Ridge, Tennessee.

There are basically six stages that new technology must move through before implementation on a power system. First, there must be conceptual design followed by development of a laboratory prototype and then laboratory testing. After the prototype is proven in the laboratory, a field prototype is developed followed by field testing. The last stage is field trials of the device on a power system. TPET provides a field test platform that mimics the real world electrical environment under more controllable conditions. TPET is needed to ensure that the laboratory prototype (or alpha version) is ready for operation and testing in a utility's substation. Thus, the goal is to accelerate field testing of a prototype (see Figures 1 and 2).

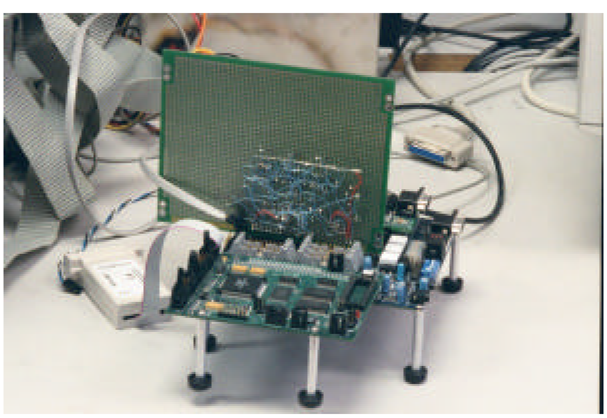

Figure 1. Prototype of a multilevel inverter built by ORNL.

Figure 2. Goal is to accelerate application in the field such as at the substation shown.

Traditionally emerging medium/high voltage power electronic systems undergo field demonstration at utility sites to both verify that it works as it should, to work out the faults, and to obtain performance data that can demonstrates viablity and reliability to the utility industry. Thus, field demonstrations of a new technology represent invaluable opportunities for product development and verification. However, the actual exposure to a wide range of events is unlikely due to the infrequency of system faults and the unpredictable nature of their severity and duration. Also, the utility industry, being conservative and careful, is slow to except new technologies without evidence of operability under a full range of events. Thus, it usually takes multiple demonstrations of a new technology in various settings over long periods to encourage utilities to consider evaluation. Additionally, system or load parameters at these demonstration sites may represent only a narrow envelope of operating conditions for the technology.

Design

Initially, the TPET will be designed to provide a fully controllable 15 kV Class utility distribution feeder for performing Device Under Test (DUT) conditions to closely mimic real world events. These include such DUT conditions as: single phasing, voltage transients, load transients, unbalanced conditions, verify energy storage charge/discharge rate, EMI emission, immunity performance, device response time, coordination with protection devices, and others.

Figures 3 and 4 show some TPET design options.

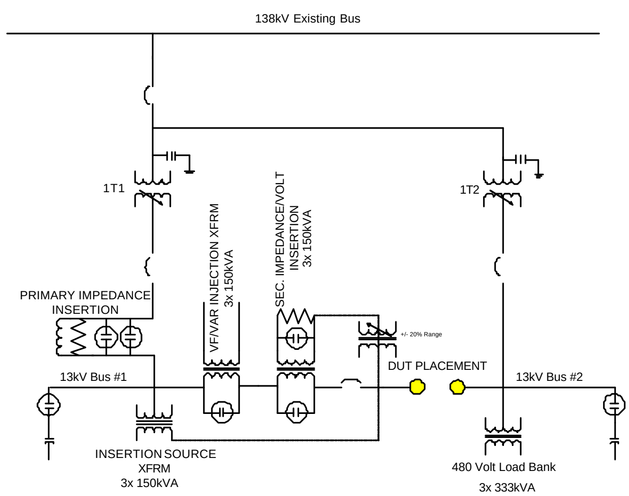

Figure 3. DUT current loading through variable tap adjustment in T1 and T2.

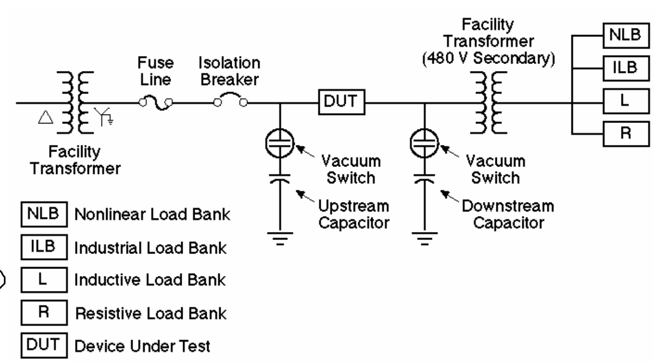

Figure 4. DUT current loading using low-voltage load banks.

Tests

Field testing at TPET will include (1) base-line performance characterization, (2) device functionality performance characterization, (3) immunity performance characterization, and (4) emission performance characterization. Base-Line Performance (BLP) Characterization Tests will characterize the steady-state performance of the power electronics and its ability to be placed it into and removed from service without interrupting the power system or loads, and determine its response to internal faults. Device Functionality Performance (DFP)

Characterization Tests will evaluate the primary and secondary functionalities of the device. Immunity-Performance (IP) Characterization Tests will evaluate the survivability of the power electronics device in a normal electrical environment without affecting itself or any loads. Emission-Performance (EP) Characterization Tests will evaluate the extraneous disturbance caused by the device that may impact the operation of other distribution system equipment or end-use loads.

The type of baseline characterization testing that can be performed at TPET will include:

- line synchronization
- response to normal voltage variation,
- response to source voltage unbalance,
- response to source voltage harmonics,
- response to unbalanced load phase current,
- response to source voltage swell,
- response to AVC band change,
- response to utility capacitor-switching transients,
- response to utility-side capacitor-switch restrike on opening,
- response to downstream capacitor-switching transient,
- response to downstream transformer energization,
- response to voltage sags and momentary interruptions,
- response to load side faults, normal removal from service,
- response to internal fault, effect of change in available utility fault duty,
- response to multiple sags due to utility recloser operation,
- response to step-loading and loss-of-load

Emission performance (EP) and immunity performance (IP) testing will include at the very least the following standard tests indicated in Table 1.

Test	**Standard**	**Category**
Audible Noise	ANSI/IEEE C37.082-1982	EP
Telephone Interference	IEEE Std 469-1988	EP
High Frequency Radiated Emission	IEC 61800-3 Sec 6.2.1	EP
Power Frequency Electrical and Magnetic Field	IEEE Std 644-1994	EP
Immunity to Radiated Electro Magnetic Interference	IEEE C37.90.2-1995	IP
Voltage Fluctuations	IEC 61000-3-7	EP
Conducted High Frequency EMC Immunity	IEC 61800-3	IP
Effect of Lightning-Induced Surges	IEEE C62.41.1 & C62.41.2, IEEE Std 1243-1997, IEEE Std 1410-1997	IP

The TPET is currently moving from concept stage to a preliminary field test protocol for a static voltage restoration device. In FY04, TPET activities will include final site selection, engineering design, equipment specification, installation of relay and equipment and instrumentation, and startup of testing.

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