TRANSMISSION & DISTRIBUTION WORLD

Entergy Stabilizes Voltage with D-VAR

D-VAR® solution regulates voltage levels by injecting VARs into the Natchez power grid.

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LOCATED ON A BLUFF OVERLOOKING ONE OF THE WIDEST BENDS OF THE MISSISSIPPI RIVER, Natchez is one of Mississippi's oldest cities. With its bustling tourism, strong industry and wealth of natural resources, Natchez is a desirable, small city — with a population just under 20,000. The Natchez area is served by five 115-kV transmission lines, the Natchez 75 megawatt (MW) gas-fired steam electric station (SES) and the Murray 20 megawatts hydro facility.

Entergy Mississippi Inc. (Jackson, Mississippi, U.S.) provides electricity service to approximately 427,000 customers in Mississippi across 45 counties, including Adams County in which Natchez is located. In 2005, while studying the possibility of placing the 75-MW fossil unit in reserve, Entergy identified potential dynamic voltage stability issues in the Natchez area.

PROBLEMS ON THE HORIZON

Although approximately 20 MW of generation support was still available from the nearby Murray hydro plant, steady-state studies revealed that with the Natchez SES in reserve, there could be thermal overload and low-voltage issues in the area under N-1 contingency conditions at the time of peak demand on the system. And with no reactive power support from Natchez SES, dynamic studies showed that the single-contingency loss of any one of the five lines feeding into the area could cause low voltages at various substations and slow voltage recovery following a fault. Without additional reinforcements, the dynamic studies showed that the voltage would fail to recover following a fault because of the increased reactive power demand from the area induction motor load.

Dynamic D-VAR solution regulates and stabilizes voltage levels by injecting VARs into the power grid at precise locations where voltage problems can occur. The D-VAR pictured is not identical to the Entergy deployment at Natchez. (Photo courtesy of American Superconductor)

Entergy determined the potential thermal overload issues could be mitigated through normal transmission reinforcement practices. Entergy conducted a feasibility study to determine if the existing 75-MW generator at Natchez SES could be converted to a synchronous condenser. The study revealed that, due to stator and rotor issues, the synchronous condenser solution would not be economical. Therefore, Entergy decided to investigate innovative solutions to address the more serious dynamic voltage stability issue.

AN EFFECTIVE SOLUTION

Voltage instability and collapse, resulting either from a lack of reactive power (VAR) support (contingencies) or from characteristics of customer load, have long been a reliability threat. Recent trends in grid development and growth in electricity demand further exacerbate these problems, making them a high priority for the electric utility industry.

Entergy system plans stipulate that sufficient reactive capacity shall be provided within the system at appropriate locations to maintain transmission-system voltages within +5% or –8% of nominal voltage under contingencies. Entergy's criteria for dynamic response are in accordance with the Western Electricity Coordinating Council's (WECC) criteria for voltage recovery.

After Entergy identified the dynamic voltage problems in the Natchez area, the utility determined solution sets that would provide effective voltage regulation under contingencies reasonably foreseeable through the summer of 2015. Given that a synchronous condenser was ruled out as a potential solution, the dynamic injection of VARs became a logical choice. The final recommendation was to install two 8-MVAR dynamic-VAR (D-VAR) units from American Superconductor Corp. (AMSC; Devens, Massachusetts, U.S.) at the 115-kV Natchez Station along with two l-MVAR capacitor banks.

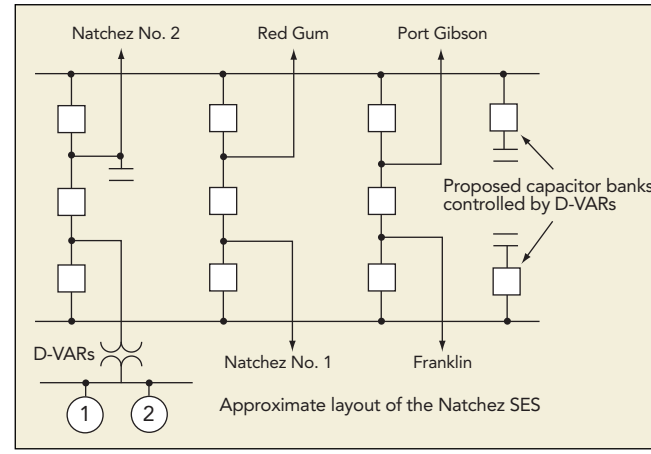
The two D-VAR units control the local transmission voltage during contingencies and restore voltage to an acceptable level. The D-VAR units also control one of the capacitor banks, using it as a "contingency bank" to augment the VAR injection from the D-VARs during severe voltage dips. The selection of this particular solution was also bolstered by the fact that Entergy already had successful field experience with similar flexible ac transmission system (FACTS) devices such as static VAR compensators (SVCs) installed in Ninemile Station near New Orleans, Louisiana, U.S., and in the Woodlands area just north of Houston, Texas, U.S.

OUT IN THE FIELD

Using control and monitoring software, the D-VAR system detects and compensates for voltage disturbances by injecting leading or lagging reactive power — measured in VARs — where it is needed on the grid. These systems are scalable and can be deployed as a single large-block solution or distributed in a load area. And, inasmuch as they are modular, they can be expanded or relocated to meet future requirements.

The D-VAR solution employed by Entergy delivers continuous reactive power, controls each phase individually and has overload capability. Typically, reactive power compensation from the unit is switched on when the nominal voltage drops below a predetermined level and switched off when voltage returns to an acceptable level near the nominal voltage. At the 115-kV Natchez Station, when an undervoltage is detected, the inverter will operate continuously to provide reactive power in conjunction with the capacitor bank. If the inverter is only operated for a relatively short interval in emergency mode, the inverter may be operated in overload fashion to provide a maximum amount of reactance. Alternatively, the inverter can be operated in a steady-state mode to provide a lower reactance level over an indefinite duration.

The D-VAR solution at Natchez is capable of attenuating rapid voltage variations and can provide post-fault voltage support to mitigate any tendency for voltage collapse. The solution also functions as a fast transient voltage support device. By integrating the D-VAR output of the reactive power compensation device with mechanically switched capacitor banks, this solution is an economical alternative to SVCs and equally effective at solving common transmission grid problems such as voltage instability and voltage regulation.



Schematic of D-VAR solution at Natchez SES.

INCREMENTAL CONTROL AND ECONOMICS

Historically, SVC and static synchronous compensator systems have provided the rapidly changing VARs needed to regulate voltage and quickly drive post-contingency voltages to acceptable levels. The time frame required for the solution's response is on the order of a few line cycles of ac power (one line cycle is 16.7 msec for 60-Hz ac power systems), even though they are capable of responding on a subcycle basis.

Entergy determined AMSC's solution was the most cost effective and had the fastest delivery time of all the possibilities. Both of the D-VARs were originally located in Entergy's transmission network in Texas and were operated as dynamic superconducting magnetic energy storage (D-SMES) units. Subsequent to the installation of the SVC in the Woodlands area, the D-SMES units were no longer needed there. After the decision to make use of the D-SMES units in Natchez for voltage support, the units were refurbished at AMSC and moved to Natchez to be operated as D-VAR units. Entergy saved a significant amount of capital expenditure by refurbishing and moving these units to Natchez. Other economic factors evaluated by Entergy included permitting (none required), environmental ratings, physical infrastructure (easily located in substations), and remote monitoring and control capability. TDW

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Vicinity map of the Natchez area transmission lines and stations.