

PureWave DSTATCOM® Distributed Static Compensator

Voltage support for transmission systems



The Need for Voltage Support

Reactive power is essential to maintain and control voltage in ac electrical systems. The ability to meet the demand for rapid changes in reactive power prevents instability, voltage sags, even voltage collapse . . . and the resultant outages to generation facilities, transmission and distribution equipment, and connected loads of industrial, commercial, and residential power users.

In the past two decades, load has been dropped in a number of instances because of delayed voltage recovery following a major transmission system disturbance. Conventional means for preventing such occurrences—shunt capacitors, reactors, and synchronous condensers—operate much too slowly. Newer technology, such as the RED PureWave DSTATCOM® Distributed Static Compensator, offers a better solution to voltage stability problems.

PureWave DSTATCOM Improves System Stability

The PureWave DSTATCOM is a fast-compensating reactive power source that can reduce voltage variations and voltage instability in the transmission system, and can assist in quick recovery after contingency events.

In systems with widely dispersed generation facilities, distributed fast-compensating reactive power sources like PureWave DSTATCOMs can provide real-time voltage control, and improve both power factor and system voltage stability. And they can reduce the impact of fluctuations in distributed generation sources on the distribution system, as well as help meet steady-state system interconnection requirements.

PureWave DSTATCOM uses solid-state dc-to-ac inverters coupled to the utility system to create reactive current, supplementing conventional voltage and VAR control devices such as mechanically switched capacitor banks. Because it's inverter-based, PureWave DSTATCOM can provide leading or lagging VARs in less than $\frac{1}{4}$ cycle . . . a fraction of the time required by conventional solutions. When appropriate, PureWave DSTATCOM can be used to operate mechanically switched capacitor banks too, creating systems that perform voltage regulation seamlessly over wide swings in utility system conditions, at low overall cost.

PureWave DSTATCOM provides flexible voltage control for transmission and distribution systems to improve line capacity utilization, shorten voltage recovery time for improved voltage stability, and minimize energy losses.

Easier to Site, Less Costly to Install in Transmission System Applications

In this era of concern about the reliability of the bulk power system, increasingly-interconnected transmission systems must provide a stable platform for power transfers while planning for a wider range of contingency events. Land acquisitions for large, costly, centrally located fast-compensating reactive power sources such as SVCs and STATCOMs can be difficult and expensive to obtain, especially in large metropolitan areas. The system interconnections for these devices often limit their effectiveness to a narrow range of contingency events as well.

Also of concern are the performance criteria being developed by organizations such as the North American Reliability Corporation (NERC) in the United States. NERC regional entities and transmission utilities have specific requirements for voltage recovery following a disturbance. Requirements for the Western Electricity Coordinating Council (WECC), for example, require voltage recovery to 80% of nominal in times less than 10 cycles (167 ms) and recovery to 1.0 per unit voltage in less than 30 cycles (500 ms).

Modular voltage compensation systems with fast response times, strategically distributed throughout the transmission system, can help meet voltage recovery requirements.

PureWave DSTATCOM readily addresses these issues. It can be deployed in existing substations, providing heightened ability to respond to a wide range of contingency events. With such *distributed compensation*, redundant systems are possible and projects can be phased in over a number of years, reducing capital expenditures.

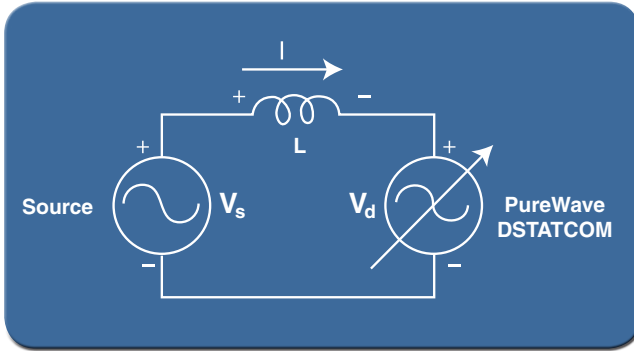


Consider a study performed to determine how three PureWave DSTATCOMs, working in conjunction with mechanically switched capacitor banks, would improve voltage recovery performance on a 138-kV/34.5-kV system, shown on the right. The PureWave DSTATCOM locations were based on the availability of space in existing substations, as well as on the effects of voltage sags on the transmission system under normal and contingency conditions. The voltage recovery graph below illustrates that with no compensation on the 138-kV/34.5-kV system (the blue curve), voltage recovery takes more than one second . . . unacceptable performance under WECC guidelines. But

[illegible]

How It Works

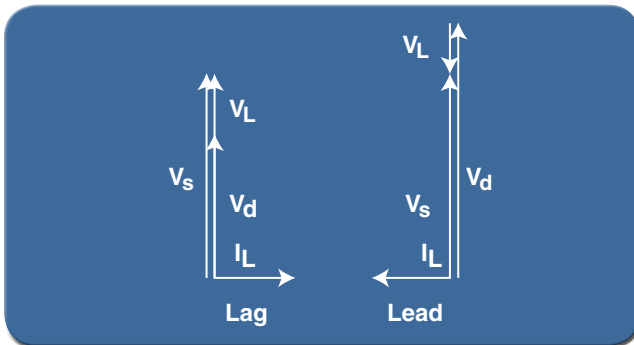
The equivalent circuit of a power system with a PureWave DSTATCOM is shown below.



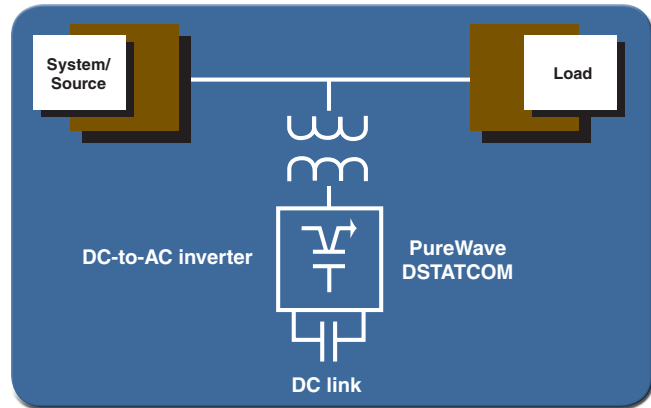
PureWave DSTATCOM generates a variable voltage, V_d , that is very nearly in phase with the source voltage, V_s . The inductance in this simplified circuit, L , consists of the inductance of the coupling transformer and filter. The voltage across the inductance, V_L , equals $V_s - V_d$ and is small in per-unit terms . . . on the order of 5-20%.

If $V_s > V_d$, V_L is in phase with V_s and current I_L lags V_s by 90° ; PureWave DSTATCOM, acting as a generator, produces leading (inductive) reactive current.

If $V_s < V_d$, V_L is antiphase with V_s and current I_L leads V_s by 90° ; PureWave DSTATCOM produces lagging (capacitive) reactive current.



PureWave DSTATCOM is connected in shunt with the load, as shown in the single-line diagram below. A step-up transformer matches PureWave DSTATCOM output to system voltage.



PureWave DSTATCOM consists of the following major components:

- IGBT-based dc-to-ac inverters, which create an output voltage wave that's controlled in magnitude and phase angle to produce either leading or lagging reactive current, depending on the compensation required.
- An L-C filter, which reduces harmonics and matches inverter output impedance to enable multiple parallel inverters to share current.
- Controls, which switch PureWave DSTATCOM modules as required. They can control external devices such as mechanically switched capacitor banks too.

Features

480-Volt Output

PureWave DSTATCOM is offered with 480-V output voltage that can be connected to systems up to 35 kV using a single step-up transformer, for distribution substation, collector systems, or industrial applications.

Often the DSTATCOM output, transformed to distribution voltages, can be connected to the secondary side of an existing transmission system transformer. This eliminates the need for additional transformers and does not affect the normal operation of the existing transformer—resulting in substantial cost savings and a reduction in installation time.

Modular Design

The modular design of PureWave DSTATCOM is economical . . . it can be tailored to the exact needs of each application. DSTATCOM can be furnished in steady-state or continuous ratings up to ± 10 MVAR in a single container, in increments of ± 1.25 MVAR.



Small Footprint

A ± 10 -MVAR PureWave DSTATCOM with 264% short-time rating can be installed in a $45' \times 12'$ building. A similarly rated static VAR compensator—with its thyristor-controlled reactors and capacitors, valves, and cooling system—has a footprint of nearly $90' \times 90'$! The compact PureWave DSTATCOM allows dynamic VARs to be placed exactly where they're needed, in a smaller package . . . and in existing substations.

Enclosure Options

PureWave DSTATCOM can be housed in a conventional enclosure or in a standard ISO container for ease of transportation and siting. Up to four enclosures can be paralleled for higher system output.



Benefits

Improved Voltage Stability

PureWave DSTATCOM can provide transmission systems with the dynamic VARs needed to counter fast voltage-collapsing events. For wind parks, DSTATCOM compensates for the continuously fluctuating reactive power demands, allowing them to meet utility interconnection requirements for power factor, voltage regulation, and low-voltage ride-through.

Increased Capacity

The reactive power compensation provided by PureWave DSTATCOM allows equipment and components to be sized more closely to the actual requirement of the load . . . not to meet additional reactive power demand. On existing systems, the additional VAR support provided by PureWave DSTATCOM may make it possible to defer new capacity additions.

Higher Reliability

VARs available closer to the customer or the reactive load provide greater stability and reliability than VARs produced on the transmission system at a distance, due to the elimination of system losses. And with *distributed compensation* installed throughout the transmission system—rather than in a single large installation—you're assured that some dynamic VARs are always available . . . even during system maintenance and unanticipated contingency events.

Substantial Short-Term Rating Capability

As shown on the right, PureWave DSTATCOM can provide up to 264% of rated output for 2 seconds—rapidly restoring transmission system voltage to precontingency conditions. The accurate modeling of system response during transient events depends not only on the available generation, but the composition of the load. Complex load models often underestimate the behavior of small motors such as single-phase air conditioners and refrigerators during transient events. Voltage sags can cause motor stalling and significantly higher short-term active and reactive VAR requirements than most models predict. The need for more “fast VARS” is often underestimated.

In addition, because much of the need for reactive power comes from the distribution system, locating a source of reactive power closer to the need makes sense—and DSTATCOM is ideally suited for this application.

Versatile Operation

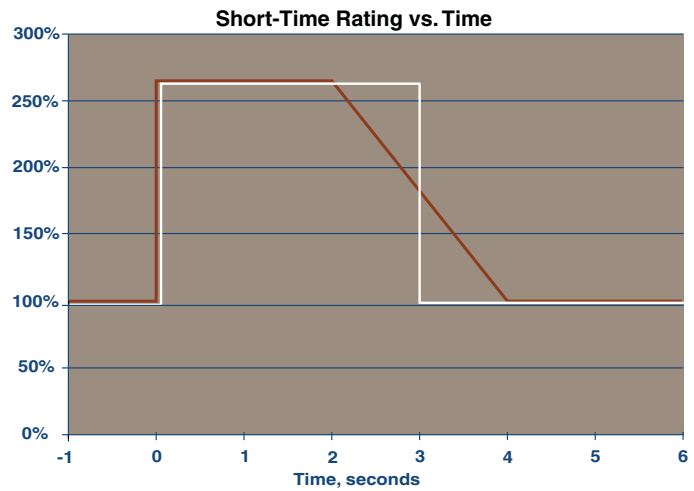
PureWave DSTATCOM has two operating modes: voltage control for steady-state or transient voltage regulation, and reactive power output control. The control interface includes a PC-based display showing equipment conditions and parameters on a real-time basis, and provides data-logging capability.

Remote Monitoring and Control Adjustments

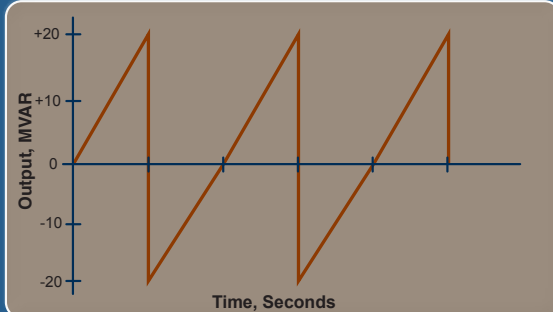
PureWave DSTATCOM is capable of automatic operation without operator intervention. When desired, monitoring and control adjustments can be made at the interface, or remotely via modem connection or a DNP 3.0 SCADA interface. Built-in diagnostics permit quick resolution of problem conditions. The SCADA interface also allows PureWave DSTATCOM to coordinate with other devices.

External Capacitor or Inductor Bank Control

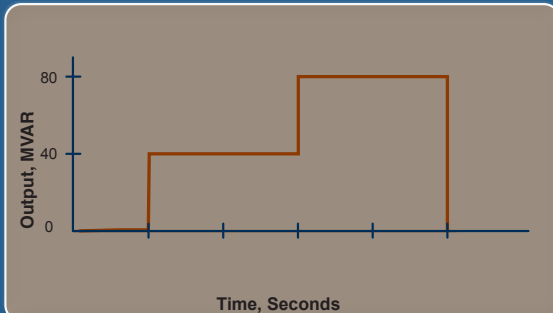
When required, PureWave DSTATCOM can be used to control externally switched capacitor or inductor banks, providing additional compensation at lower cost than an inverter-based system alone. In the example shown on the right, PureWave DSTATCOM output is coordinated with that of several external capacitor banks to provide a continuous range of VAR support. By using a combination of “fast” and “slow” VARs, a system can be created with subcycle response time and a smooth continuous output across the entire VAR range . . . at significantly lower cost than a “fast” VAR system alone.



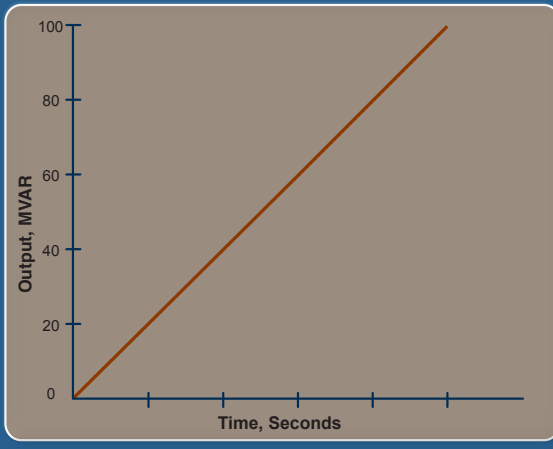
DSTATCOM Output



Switched Capacitor Bank Output



VAR System Output



Specifications	
System Voltage Continuous Output	480 V to 35 kV, 50 or 60 Hz★
Short-Term Current Rating	264% for 2 seconds, ramping to 100% at 4 seconds; or 264% for 3 seconds, stepping directly to 100%
Reactive Current Response Time	2 to 4 milliseconds
Inverter	IGBT, pulse-width modulated at 4860 Hz
Temperature Range	-40° to +50° C
Efficiency	>98% typical
Cooling	Ambient air cooling

★ Single transformation.

Dimensions and Weights of Pre-packaged ISO-Style Enclosures (Typical)					
System Rating, MVAR	Number of Containers	Dimensions, Feet (Meters)			Weight, Pounds (kg)
		L	W	H	
5.0	1	40 (12.2)	8.0 (2.4)	9.5 (2.9)	36,000 (16,364)
7.5	1	45 (13.7)	8.0 (2.4)	9.5 (2.9)	48,000 (21,818)
10.0	Container 1: Lead, 10 MVAR	45 (13.7)	8.0 (2.4)	9.5 (2.9)	48,000 (21,818)
	Container 2: Control	20 (6.1)	8.0 (2.4)	9.5 (2.9)	14,000 (6,363)
15.0	Container 1: Lead and controls, 7.5 MVAR	45 (13.7)	8.0 (2.4)	9.5 (2.9)	48,000 (21,818)
	Container 2: Auxiliary, 7.5 MVAR	40 (12.2)	8.0 (2.4)	9.5 (2.9)	36,000 (16,364)

RED Is Your Total Power Quality Services Provider

RED can complete your power quality project on a turnkey basis, in which case we'll take full responsibility for ensuring all steps are completed in accordance with your plans and specifications.

A typical turnkey project includes five major steps:

- Analytical studies, engineering design, and installation documentation, including drawings, specifications, and bills of material;
- Procurement of major equipment such as transformers and cable;
- Construction, including site preparation, erection of steel structures, and equipment installation using RED-supervised contractors;
- Acceptance and in-service testing of all equipment; and
- Commissioning, including all steps necessary for equipment transfer, including documentation, test reports, and project as-built drawings.

RED project and construction managers have the wide array of skills needed to complete turnkey projects on-time, per your requirements.



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