When the STATCOM is applied in distribution system is called **DSTACOM** (Distribution-STACOM) and its configuration is the same, or with small modifications, oriented to a possible future amplification of its possibilities in the distribution network at low and medium voltage, implementing the function so that we can describe as flicker damping, harmonic filtering and hole and short interruption compensation.

**Distribution STATCOM (DSTATCOM)** exhibits high speed control of reactive power to provide voltage stabilization, flicker suppression, and other types of system control.

The **DSTATCOM** utilizes a design consisting of a GTO- or IGBT-based voltage sourced converter connected to the power system via a multi-stage converter transformer.
DSTATCOM (Distribution Static Compensator)

The DSTATCOM protects the utility transmission or distribution system from voltage sags and/or flicker caused by rapidly varying reactive current demand. In utility applications, a DSTATCOM provides leading or lagging reactive power to achieve system stability during transient conditions.

The DSTATCOM can also be applied to industrial facilities to compensate for voltage sag and flicker caused by non-linear dynamic loads, enabling such problem loads to co-exist on the same feeder as more sensitive loads. The DSTATCOM instantaneously exchanges reactive power with the distribution system without the use of bulky capacitors or reactors.

In most applications, a DSTATCOM can use its significant short-term transient overload capabilities to reduce the size of the compensation system needed to handle transient events. The short-term overload capability is up to 325% for periods of 1 to 3 seconds, which allows applications such as wind farms and utility voltage stabilization to optimize the system’s cost and performance. The DSTATCOM controls traditional mechanically switched capacitors to provide optimal compensation on a both a transient and steady-state basis.
DSTATCOM (Distribution Static Compensator)

A typical control circuit of the D-STATCOM
The three-phase load currents to be compensated (iLa, iLb, and iLc shown in the last Figure) are measured from the system and transformed to two phase orthogonal components (ip and iq) on rotating coordinates synchronized with the line voltage. The outputs of the filter circuit are inversely transformed to three-phase components (isa, isb, and isc shown in Figure). The output current of the D-STATCOM is controlled by three-phase current feedback control using isa, isb, and isc as reference signals for each phase. The output signals of the current control added by a sensed system voltage signal becomes the voltage reference signal of the PWM control. The PWM control circuit generates the firing signal of the GTO by comparing triangular wave carrier signals to the voltage reference signal.
DSTATCOM (Distribution Static Compensator)

For weak distribution systems where the operation of arc furnaces causes significant power quality problems, a high performance flicker compensation device is necessary. As a solution to this particular power quality need, the DSTATCOM has been applied for a number of situations and has provided excellent performance for arc furnace flicker suppression. The Figure shows the system configuration for a flicker compensation installation.

System configuration for arc furnace flicker compensation application
The flicker caused by the arc furnace operation was measured by use of a flicker meter. The output of the meter was $\Delta 10$, and was used as an indicating factor of voltage flicker. The voltage deviation of the meter from the reference value is calculated for each cycle. It is then filtered by a human eye sensitivity curve and integrated for one minute to output a value for $\Delta 10$.

The table shows the maximum values and the improvement ratio for operation of the DSTATCOM to compensate the flicker. In this application, the flicker suppression realized was 58% on average with utilization of the DSTATCOM. In this case, the capacity of the DSTATCOM was 21% of the maximum reactive power generated from the arc furnace. The measured results clearly indicate the high performance achieved by the DSTATCOM for flicker suppression.
DSTATCOM (Distribution Static Compensator)

(a) Without D-STATCOM

(b) With D-STATCOM

Voltage flicker without (top) and with (bottom) a DSTATCOM on the same voltage scale
To prevent the unbalanced and distorted currents from being drawn from the distribution bus, a shunt compensator, **DSTATCOM**, can be used to ensure that the current drawn from the distribution bus is balanced and sinusoidal. A Voltage Source Converter (VSC) is used to realize a **DSTATCOM**. The structure of the VSC decides the extent of compensation it can provide.

- Inverters rated 2 MVA are applied in 2-, 4-, 6-, and 8-MVA systems that protect the distribution system from non-linear dynamic loads of 4 to 24 MVA.
- Inverters rated 5 MVA are applied in 5-, 10-, 15-, and 20-MVA systems that protect the distribution system from non-linear dynamic loads of 5 to 60 MVA.
The DSTATCOM is connected in parallel with the non-linear dynamic load. When appropriate, the VSI synthesizes a current waveform of controlled magnitude, frequency, and shape. The parallel insertion transformer "adds" and scales this synthesized waveform and superimposes it upon the load current. The DSTATCOM responds in less than a 1/4 of a cycle to maintain bus voltage, thus eliminating flicker resulting from sudden changes in reactive power demand.
DSTATCOM. Simulation

DSTATCOM using three-leg VSC with single dc capacitor.

**Network:** $Ra=Rb=Rc=2\ \Omega$, $La=Lb=Lc=0.01\ H$

**Load:** $Ra=2\ \Omega$, $Rb=0\ \Omega$, $Rc=0.5\ \Omega$, $La=Lc=0.01\ H$, $Lb=0\ H$
Load currents charts for the three phases. We can see the non sinusoidal, unbalance and distortion produced by the load.

We use a PSIM software based in Matlab for to obtain, by a time-step simulation, the evolution of different parameters.
Load voltage charts for the three phases. We can see the non sinusoidal, unbalance and distortion produced by the load.
Charts of the three phases inject currents in the PCC by the VSI.
Charts of the three phases voltages at the VSI.
Charts of the three phases currents at the PCC. We can see the effect of the DSTATCOM.
Charts of the three phases voltages at the PCC. We can see the effect of the DSTATCOM.
We have analyzed the operation of a DSTATCOM using three-leg VSC with single dc capacitor. The operation of the switches S1–S6 depends on the control strategy used.

Since there is no return path for the zero sequence component of the currents, the three-leg VSC with single dc capacitor cannot inject currents having a zero sequence component. 

\[ I_{1a} + I_{1b} + I_{1c} = 0 \]

Hence, there will be a zero sequence component in the load current if the load is unbalanced. Full compensation will not be possible as the zero sequence component in the load current cannot be compensated. Hence, the application of this topology is limited.
The picture shows a DSTATCOM with a three-leg VSC with neutral clamped dc capacitor.
The last structure shows the circuit of the three-leg VSC with neutral clamped dc capacitor. The neutral of the load and the neutral of the dc capacitors are connected together. If the load is unbalanced, the load current will have a zero sequence component and the compensator will be required to supply this zero sequence component. As there is a path for the zero sequence component to return to the compensator, the compensator will be able to compensate for unbalanced loads.

The final choice of the dc capacitor value for the DSTATCOM will depend on the energy storage for the transient ride through support that the DSTATCOM is required to provide to the main ac system.