

# DS1 diode-based transient-free capacitor switch

## Key technological features

This paper describes the key technological features of the DS1 making it superior to all the other capacitor switches present on the market today.

Its innovative technology based on power diodes gives final customers unique benefits and advantages.



**No inrush current.**  
The impossible made possible.

DS1 has the highest synchronization precision thanks to its powerful control unit: the maximum scatter of zero crossing closing is  $\pm 0.050$  ms, much more precise than the zero voltage closing control on vacuum switches, which is usually about  $\pm 1.0$  ms. This high precision coupled with diodes technology means DS1 can perform closing operations with no appreciable inrush current which eliminates the need for inrush reactors (and the relative expense and space) in many back-to-back capacitor bank applications, while also preventing stress on the switch contacts. The DS1 pilot installation with Consolidate Edison shows, through the monitored current waveform, how the inrush peak is limited to the rated current:

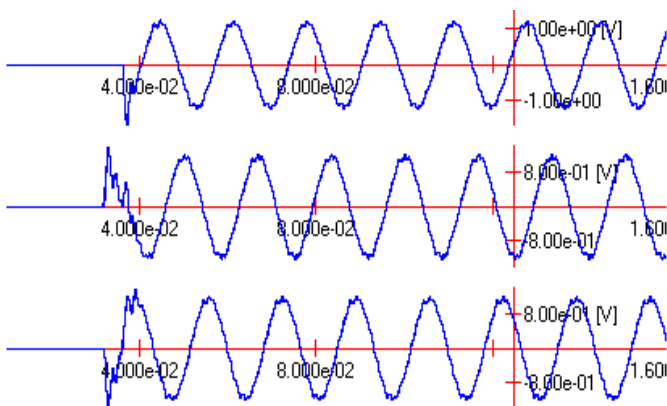


Figure 1 - ABB DS1 closing on a back-to-back capacitor bank at Con Ed Astor substation.  
Current vs. time monitoring.  
Inrush peak = 0.8 kA (approx.)

**No overvoltage.**  
Safeguarding the network.

As a result of these technological features DS1 provides a closing operation without appreciable voltage transient on the network voltage. This prevents switching disturbances affecting network reliability and stability which usually negatively impact users' businesses. Again, the pilot installation with Consolidate Edison shows, by means of the monitored network voltage waveform (on the right), how there is no overvoltage on the busbar. This can be compared to monitoring on the same busbar when closing is performed using a synchronized vacuum switch, causing an overvoltage of almost 2 pu.

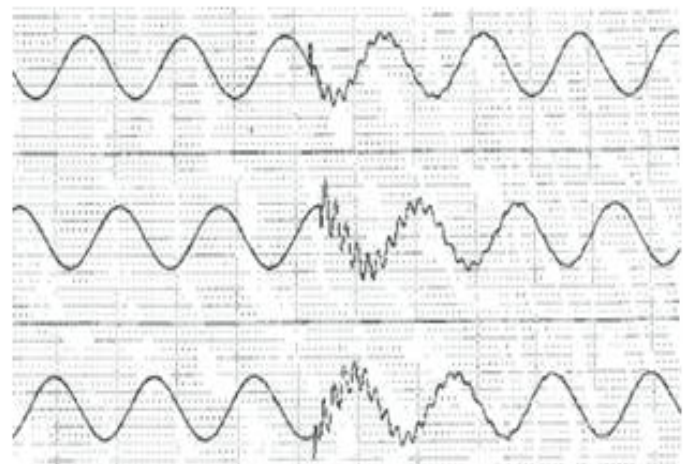
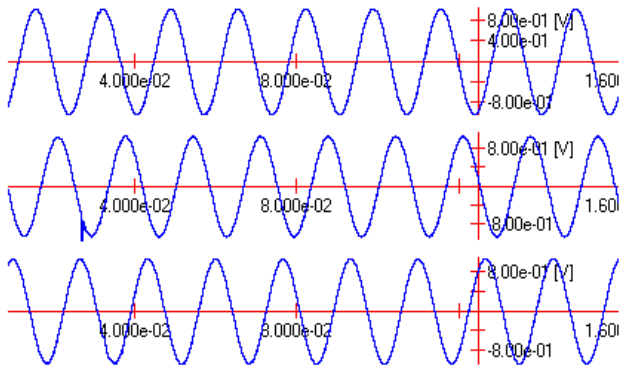


Figure 2 - Vacuum zero voltage closing on back-to-back capacitor bank at Con Ed Astor substation.  
Bus voltage vs. time monitoring.  
Overvoltage = 2.00 pu (approx.)

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**Figure 3 - ABB DS1 closing on back-to-back capacitor bank at Con Ed Astor substation.**  
Bus voltage vs. time monitoring.  
Overvoltage = 1.05 pu (approx.)

This makes DS1 the perfect solution for switching capacitor banks; in fact it avoids transients affecting network stability and reliability. In addition, it makes for longer-lasting capacitor banks thanks to the absence of stress caused by transient phenomena.

### Prestrike-free. Perfect closing.

DS1 is able to perform prestrike-free switching operations on capacitor banks. During the closing operation the diodes energize the circuit precisely from zero voltage, thus preventing the physical possibility of prestrike and the occurrence of contact welding, a typical issue with vacuum interrupters switching capacitive loads.

### Restrike-free. Beyond C2 class.

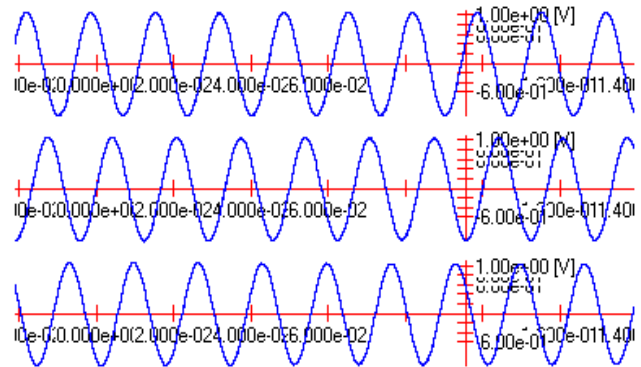
C2 class capacitor switch means, according to today's standards, a very low probability of restrike, namely less than 0.02% during capacitive switching tests. Despite DS1 having performed all the switching operations without any restrike during such tests, it has been classified as a C2 class switch, but the reason is that there is currently no standard for this kind of apparatus. In fact, during opening, the diodes block the current exactly at zero thus allowing the moving contact to open a circuit with no current flowing.

In addition, the fast and controlled movement of the servomotors allows the voltage withstand of the gap between the opening contacts to increase faster than the voltage stress between them.

This results in the physical impossibility of a restrike during an opening operation.

A specific capacitive switching class should be introduced to the standards to regulate apparatuses such as DS1, where there is no physical possibility of restrike occurring.

Also, no overvoltage is caused by DS1 when performing an opening operation.



**Figure 4 - ABB DS1 opening on back-to-back capacitor bank at Con Ed Astor substation.**  
Bus voltage vs. time monitoring.  
No overvoltage.

### Integrated control unit. Plug&Switch.

DS1 is fitted with an electronic control unit which provides switch diagnostics and system coordination logics, as well as a synchronization feature. The control unit is integrated inside the DS1 and is configured and tested at the manufacturing stage. This makes installation of the DS1 fast and easy with no need for calibration at start-up.

## Switch diagnostics. Reliability is the word.

The DS1 control unit provides diagnostics on the status of the entire apparatus.

The parameters it controls are:

- Status of the kinematic chain
- Accuracy of the last operation
- Status of the servomotors
- Presence and accuracy of the synchronization signal
- Dry air pressure
- Status of the actuation capacitor
- Status of the control unit.

All these monitoring functions are communicated to the user by means of binary outputs. They can be easily combined to give different visible outputs both locally and remotely.

Thanks to the DS1 diagnostics, any potentially dangerous operation can be prevented thus guaranteeing extreme operation safety and reliability. The user is also constantly informed on the status of the switch.

Please refer to the DS1 catalogue for additional information on switch diagnostics.

## Interlocks. Safe & Easy system integration.

DS1 is easy to integrate into any system thanks to the flexible control unit built-in to the switch. In fact, apart from standard open and closed inputs, it is able to receive an interlock input which can be coordinated using system logics in any required hierarchy.

For example, DS1 operation can be prevented if the upstream protection circuit breaker is operating or if the capacitor earthing switch is closed.

This makes the DS1 perfect for easily and safely integrating into a substation or plant protection and actuation logics.

## Brushless servomotors. Reliable actuation.

DS1 actuation is performed by brushless servomotors controlled and monitored by the integrated control unit.

Servomotors are known to be highly reliable, in part thanks to the possibility of performing diagnostics on them. In addition they are completely maintenance-free.

Synchronization requires single-phase actuation, but thanks to the continuous diagnostics of servomotors status of DS1, single-phasing is prevented.

## Mechanical endurance. Extended switch life.

The whole DS1 switch has been tested and certified up to 50,000 mechanical opening and closing operations. This makes DS1 the longest-lasting capacitor switch on the market today.

## Compactness. Space-saving.

DS1 is the most compact switch available on the market today, thanks to its reduced dimensions and integrated control unit. Its main dimensions are about 26 x 25 x 22 in (H x W x D, rounded up) with a phase-to-phase distance of less than 9 in.

This allows a saving of up to 70% of space compared to other transient-mitigating capacitor switches.

## Dry-air insulation. Eco- and user-friendly

DS1 is dry-air insulated with the pressure constantly monitored by the integrated control unit. DS1 is sealed for life (25 years), but in case of leakage, refilling is fast and easy thanks to the pressure switch inside the casing.

This means the DS1 can be put back in service very soon after leakage detection and refilling, without the need to replace the switch.

## Maintenance-free. Install, switch and forget.

DS1 is maintenance-free; in fact none of the components of the switch needs any maintenance. Periodic checking of the DS1 is limited to visual checking of the connections.

Please visit the [DS1 diode-based transient-free capacitor switch webpage](#) to find out more about ABB's application of diode technology!

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