

DS1

Technical Guideline for Installation and User Manual

Safety	3		
1. Introduction	4		
1.1 Environmental protection program	4		
1.2 Packing and transport	4		
1.3 Checking on receipt	4		
1.4 Storage	5		
1.5 Handling	5		
1.6 End of life of product	6		
1.7 Disposal methods	6		
2. Product Description	7		
2.1 General features	7		
2.2 Reference Standards	8		
2.3 Fixed capacitor-switch	8		
2.4 Main electrical characteristics	8		
2.5 Apparatus operating instructions	10		
2.6 Description of the capacitor-switch closing and opening operations	10		
2.7 DS1 Closing and Opening switching behaviour	11		
3. Description of the control and supply electrical interface	12		
3.1 Power Supply Characteristics	12		
3.2 Description of the DS1 output	12		
3.3 Electrical characteristics of the outputs	12		
3.4 Description of DS1 inputs	13		
3.5 Special INPUT - Only for commissioning and maintenance	13		
3.6 Electrical characteristics of the INPUT	14		
3.7 Input Acceptance Logic	14		
3.8 DS1 functional descriptions	14		
4. DS1 Diagnostics	16		
4.1 Base Module Diagnostics	16		
4.2 Master Diagnostics	16		
4.3 Synchronization Diagnostics	17		
4.4 Diagnostics Table	17		
5. Installation Guideline	18		
5.1 General	18		
5.2 Before installing the apparatus:	18		
5.3 Installation requirements	18		
5.4 Installation of fixed apparatus	19		
5.5 Additional installation recommendations	19		
5.6 Preliminary operations	19		
6. Fixed Apparatus power circuit connections	20		
6.1 General directions	20		
6.2 Mounting the connections	20		
6.3 Mounting procedures	20		
		6.4 Three-phase power line connections	21
		6.5 Load connection	21
		6.6 Synchronization sensor	22
		6.7 Voltage Sensor Connections	23
		6.8 Earthing	23
		6.9 Auxiliary circuit connection	23
		7. Commissioning	24
		7.1 General procedures	24
		7.2 Startup and maintenance features	24
		7.3 Pressure Monitoring	25
		7.4 Interface summary for Maintenance and Commissioning	25
		7.5 Commissioning - Test with no power, no sync	26
		8. Periodical inspections	28
		8.1 General	28
		8.2 Checking program	28
		8.3 Measurement of air pressure inside poles	28
		8.4 Dry Air filling	28
		8.5 Dry air filling procedure	28
		8.6 Measurement of resistance across closed contacts of poles	29
		8.7 Replacement due to System malfunctions	29
		8.8 Spare parts and accessories	29
		Annex A - Terminal Block for auxiliary control circuit	30
		Annex B - External drawing for DS1 Integration	31
		B.1 Overall dimensions	31
		B.2 Internal connections	31



Safety

For your safety!

Make sure that the installation site (spaces, divisions and ambient) is suitable for the electrical apparatus.

Check that all the installation, putting into service and maintenance operations are carried out by qualified personnel with in-depth knowledge of the apparatus.

To ensure that the installation conforms to the rules of good working practice and safety in the workplace, make sure that the standard and legal prescriptions are complied with during the installation work, putting into service and maintenance operations.

Strictly comply with the information given in this instruction manual.

Do not exceed the rated performance of the apparatus during service.

Pay special attention to the danger notes indicated in the manual by the following symbol:

Make sure that the personnel operating the apparatus are provided with this instruction manual as well as all the necessary information for correct operation.

Responsible behaviour safeguards your own and others' safety!

Please contact the ABB assistance service for any requests.



IMPORTANT

DS1 is a special purpose capacitor switch specifically designed to manage capacitive loads. DS1 is not designed to perform any safety function.

When a DS1 is installed in a system, the safety functions must be provided by system integration.

There must always be at least one upstream protection (e.g. a circuit breaker) and preferably also a second level of protection (e.g. fuses).

Maintenance must not be performed when the system is energized by the MV supply. In addition, coordination or security keys must always be present to prevent operator errors from causing the device to function in a situation for which it is not designed (e.g. closing on a grounded capacitor).

In general, especially when large capacitor banks are operated, the power involved, the danger of electrical phenomena and the impact of a potential failure on the capacitor bank make it very dangerous to remain near the live equipment (especially during transients).

Use of compartments able to contain the internal arc in case of failure are recommended.

Work performed by operators in rooms housing live equipment containing capacitors or operating means is always strongly discouraged.

DS1 internally creates an auxiliary voltage bus at 350 VDC. Additional energy is stored inside a capacitor. Maintenance must not be performed when DS1 is supplied and when electrical equipment must be touched (apparatus or internal auxiliary equipment). After system shut down wait at least one minute (until the control system consumes the energy stored inside the internal capacitor) for the control system to shut down (internal leds turn off) before touching any of the electrical equipment. Additional precautions for the internal capacitor must be observed, especially if it has been disconnected by the control system or if maintenance is performed for a suspected a control system failure. When performing this operation, always use all mandatory safety PPE for electrical maintenance.

1. Introduction

This publication contains the information required for installing, commissioning and servicing DS1 medium voltage special purpose capacitor switches.

To ensure the product is used correctly, please read this manual carefully.

Please refer to the relevant instructions to ensure that accessories and/or spare parts are installed correctly.


Similarly to all the apparatus manufactured, DS1 capacitor switches are designed for different installation configurations.

For this reason, the information given below does not always cover special configurations.

Apart from this booklet, it is always necessary to refer to the latest technical documentation available (circuit diagram, wiring diagrams, assembly and installation drawings, any studies of protection co-ordination, etc.), especially with regard to any modifications to the standard configurations that may be required.

System integration, installation guidelines and checks to be performed during the installation work are provided in the following section.

In addition, a description of the internal diagnostics, substation interfacing and monitoring is provided for the purpose of integrating DS1 with the remote control room.



All operations regarding installation, putting into service, operation and maintenance must be performed by suitably qualified personnel with in depth knowledge of the apparatus. Parts must only be replaced with original spares.

1.1 Environmental protection program

DS1 capacitor switches comply with ISO 14000 Standards (Environmental Management Guidelines).

The production system of the Medium Voltage factories complies with the environmental protection regulations in terms of energy consumption, raw materials and waste disposal.

The environmental impact of the product life cycle is assessed by the LCA - Life Cycle Assessment procedure, which is also the result of a well-focused design phase when it comes to selecting materials, processes and packaging.

The production techniques ensure that the components can be easily dismantled and separated at the end of the life cycle of the apparatus, while optimizing the recycling process.

1.2 Packing and transport

The apparatus is shipped in special packing in the open position with absolute pole pressure corresponding to the service value.

Each piece of apparatus is protected by plastic film to prevent water from infiltrating during the loading and unloading stages and to keep the dust out during storage.

1.3 Checking on receipt

On receipt, check the state of the apparatus, make sure that the packing is undamaged and that the nameplate data correspond (see fig. 1) to the specifications in the order acknowledgement and the delivery note.

Also make sure that all the materials described in the shipping note are included in the supply.

If damage or discrepancies are discovered when the apparatus is unpacked, notify ABB (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.


The apparatus is only supplied with the accessories specified at the time of order and confirmed in the order acknowledgement sent by ABB.


The following documents are included in the shipping packing:

- Instruction manual (this document)
- Test certificate
- Identification tag
- Fiscal copy of shipping note
- Circuit diagram.

These other documents are sent prior to shipment:

- Order acknowledgement
- Original copy of shipping note
- Drawings or documents regarding special configurations/ conditions (if applicable).



1	SPECIAL PURPOSE CAPACITOR SWITCH		
	DS1		
	CLASSIFICATION	IEC 62271-103	2
3	SN		
	INSTRUCTION MANUAL	PR. YEAR	
4	M MASS	.....	kg
	Ur VOLTAGE	.....	kV
	Up LIGHTNING IMPULSE WITHSTAND VOLTAGE	.....	kVp
	Ud POWER FREQUENCY WITHSTAND VOLTAGE	.....	kV
	fr FREQUENCY	.....	Hz
	Ir NORMAL CURRENT	.....	A
	Ik SHORT TIME WITHSTAND CURRENT	.....	kA
	tk DURATION OF SHORT CIRCUIT	.....	s
	Ip PEAK CURRENT	.....	kA
	m DRY AIR MASS FOR CAPACITOR SWITCH	.....	kg
	Pre DRY AIR RATED FILLING PRESSURE AT 20° C	.....	MPa
ELECTRICAL DIAGRAM			
			
-US AUXILIARY VOLTAGE		110...240 V ---	
Made by ABB, Italy			

Nameplate

- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Type of apparatus 2. Symbols and compliance with Standards | <ol style="list-style-type: none"> 3. Serial number 4. Apparatus characteristics 5. Characteristics of the operating auxiliaries |
|--|---|

Figure 1. Product identification label

1.4 Storage

When the apparatus must be stored for a certain period of time, our workshops can provide (on request) suitable packing for the specified storage conditions.

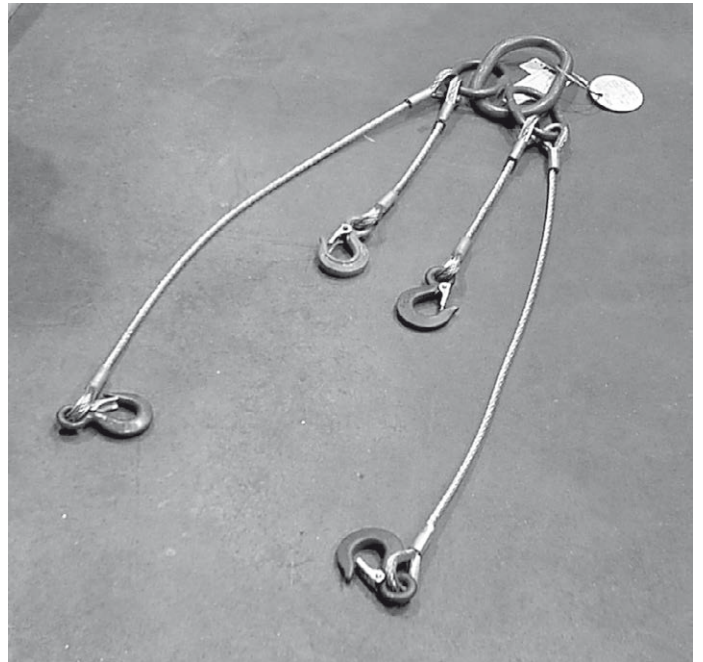
On receipt, the apparatus must be carefully unpacked and checked as described in Checking on receipt (chap. 2).

If immediate installation is not possible, apparatus must be repacked in its original packing materials.

Insert at least one packet of hygroscopic substance inside the packing of each piece of apparatus.

Should the original packing be unavailable and immediate installation is not possible, store the apparatus in a covered, well-ventilated, dry, dust-free, non-corrosive place, well away from flammable materials and at a temperature between $-15\text{ }^{\circ}\text{C}$ and $+55\text{ }^{\circ}\text{C}$.

In any case, avoid accidental impact or positions which could stress the structure of the apparatus.



1.5 Handling



Use the tool (1) in (fig. 2) to lift and handle the apparatus.

Insert the hooks (2) into the holes made in the apparatus frame and lift. Take care when lifting tools are used: the load is not perfectly balanced (it is unbalanced toward the poles). Unhook the lifting tools after having completed the operation (in any case before putting into service).

When handling the apparatus, always take great care not to stress the insulating parts or the apparatus terminals.

The apparatus must not be handled by inserting lifting devices directly under it.

If this method is unavoidable, place the apparatus on a sturdy supporting surface (see fig. 2).

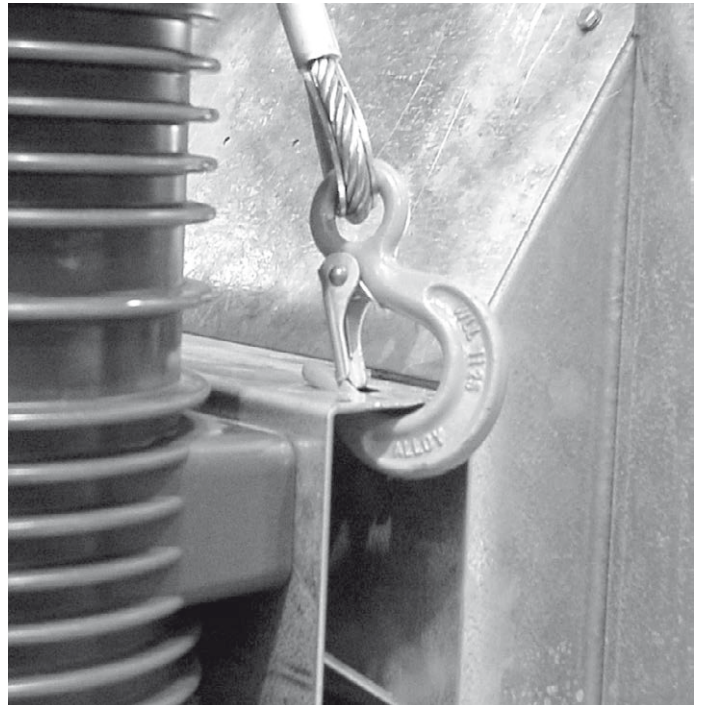


Figure 2. Hooks and lifting holes for DS1

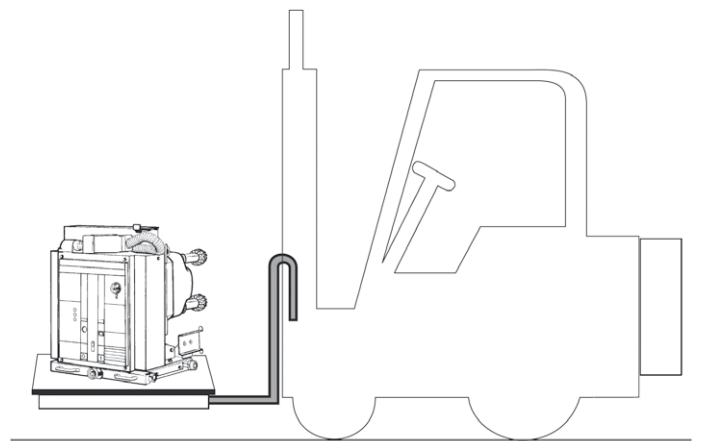


Figure 3. DS1 carrying method

1.6 End of life of product

ABB complies with the relevant laws and other environmental protection requirements in accordance with standard ISO 14 001. The duty of companies is to facilitate subsequent recycling or disposal at the end of product life. Always act in accordance with the local laws in force when disposing of the product.

1.7 Disposal methods

The apparatus can be disposed of either thermally, in an incineration plant, or in a waste site, whichever is the best solution as regards materials, limitation of environmental impact on the environment and compliance with the local laws in force.

Raw material	Recommended disposal method
Metal material (Fe, Cu, Al, Ag, Zn, W, others)	Separation and recycling
Thermoplasts	Recycling or disposal
Epoxy resin	Separation of metal material and disposal of the rest
Rubber	Disposal
Packing material – wood	Recycling or disposal
Packing material – foil	Recycling or disposal

2. Product Description

2.1 General features

DS1 are dry air insulated special purpose capacitor switches for indoor installation. Please refer to the corresponding technical catalogue code (1VCF000580) for the electrical performance data.

For special installation conditions, please contact ABB. Please also note that the **apparatus is unable to make or break fault conditions and that protection on the supply side must always be installed.**

The following photos illustrate the DS1 main assembly. DS1 is a special purpose capacitor switch specifically designed for managing capacitive loads in symmetric and balanced systems.

The load layout must be the full capacitive, star configuration and floating center-load type.

The device uses diode-switching technology and is dry air insulated (see **Pressure Monitoring** section for details).

One additional upstream voltage sensor for MV network synchronization is required for correct installation (see specific sensor characteristics in the following section).

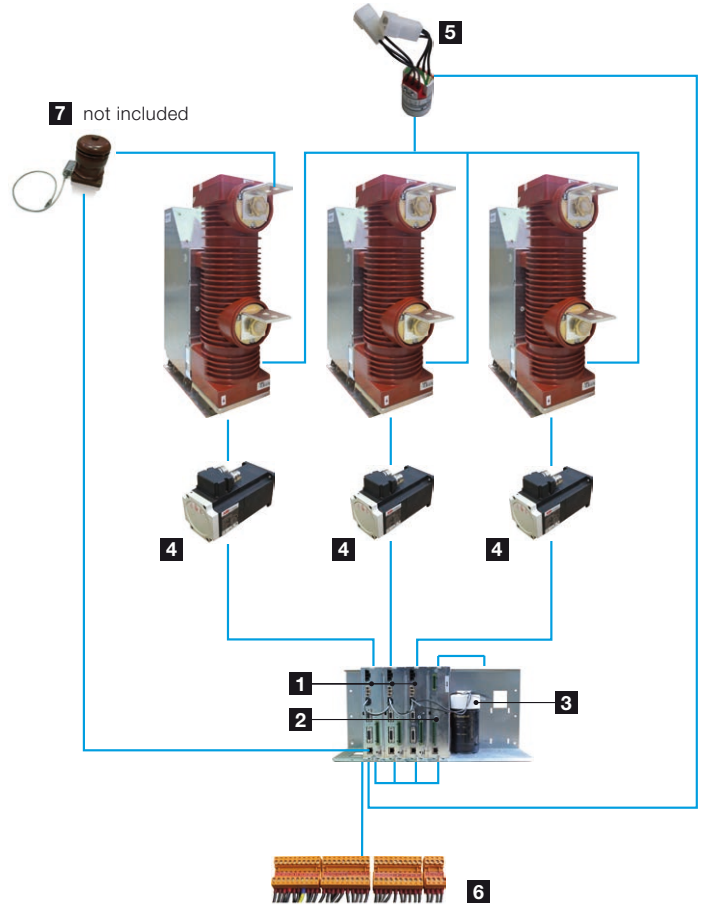
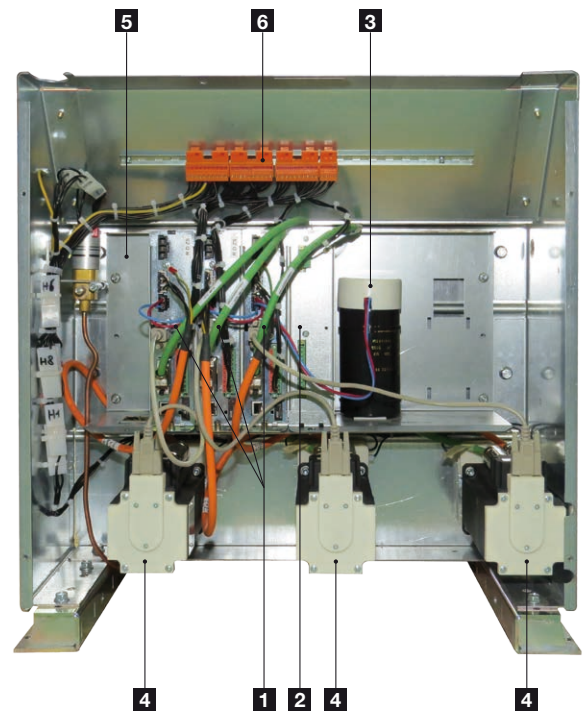


Figure 4. ABB DS1 Capacitor Switch



1. Control unit
2. Supply unit
3. Switching capacitor
4. Servo-motors
5. Pressure switch
6. Terminal block
7. Voltage sensor (not included)

2.2 Reference Standards

The DS1 series apparatus complies with the following Standards: IEC 62271-103 Special Purpose Capacitor Switch with no making and breaking capability. IEC62271-100 has been applied for capacitive switching (with some exclusions), since is more demanding.

2.3 Fixed capacitor-switch

The fixed capacitor-switch (see fig. 4) corresponds to the basic version complete with a front protection shield and frame. The anchoring holes are drilled in the lower part of the frame. The terminal board connection, fixed on the upper protection, is available for connecting the auxiliary circuits of the apparatus. The earthing screw is located on the side of the apparatus. For further details, consult the “External Drawing for DS1 Integration” at the end of this document.

2.4 Main electrical characteristics

The main electrical ratings of DS1 are:

Rated Voltage	17.5 kV at 50 Hz
	15 kV at 60 Hz
Rated current	630 A at 50 Hz
	600 A at 60 Hz
Short Time Current	20 kA for 0.5 s

Since it is a special purpose capacitor switch based on diodes for switching, **DS1 is unable to break and make a fault current**. It can switch up to its rated current, indicated above. However, it has a short time withstand current of 20 kA for 0.5 s that allows the upstream protection to operate and interrupt the fault, thus preventing the DS1 and capacitors from being damaged.

A supply side protection must always be present (circuit breaker), and it is preferable for fast fuses to be installed as well.

Additional interlocks are strongly recommended in order to prevent DS1 from operating in the following conditions:

- During a fault (when an upstream protection is tripping)
- When a downstream earth switch has not been opened (e.g. after maintenance).

DS1 has a generic interlock (Pin 10 internally performs loop with Pin 20 of terminal block) with the scope of implementing this interlocking function. See specific section.

Coordination signals and interlocks (mandatory) are described in the following section.



An additional safety interlock should be used in order to prevent DS1 from operating in the maintenance mode (due to incorrect wiring of the upstream CB interlock). See specific section for details of the upstream interlock feature.

ABB declines all liability for the product following failure to comply with these guidelines when DS1 is installed.

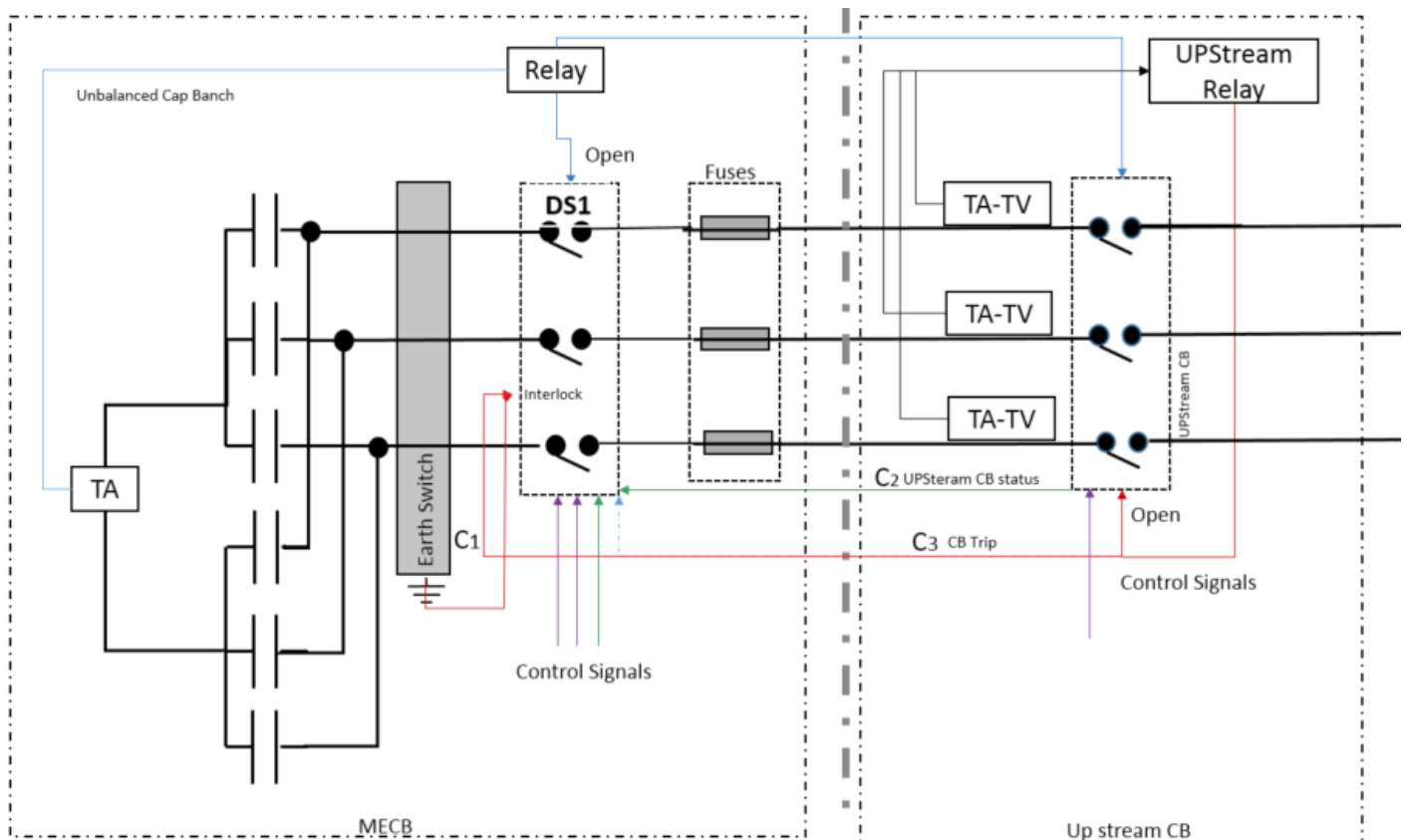
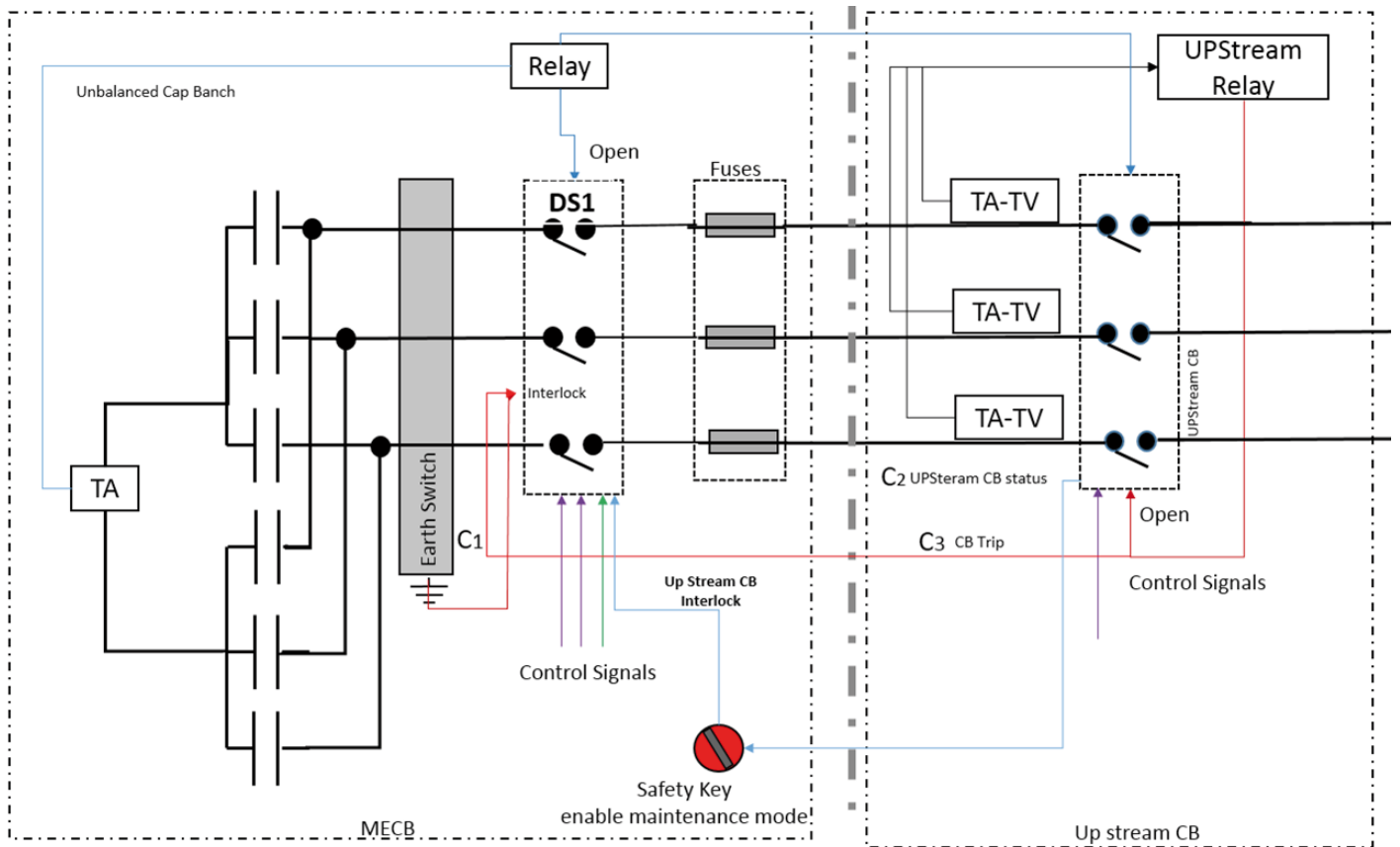


Figure 5. Typical circuit for integration with MECB



We strongly recommend use of unbalanced load protection (together with other standard protections tailored to suit the system) that functions when the upstream circuit breaker trips if the load is not balanced on the three phase system.

The capacitor bank unbalanced protection layout shown above is strongly recommended because allows a capacitor with impaired performance to be identified, thereby reducing the impact of a capacitor bank fault.

Operating Conditions:

DS1 is designed for indoor applications. The following operating conditions apply:

Maximum Operating Temperature of DS1: -15 °C +55 °C

Note: The pressure inside the device depends on the temperature. However, DS1 has been tested at minimum pressure. Please note that if unlikely circumstances occurs (temperature variation in the filling stage and tolerance of the pressure meter) when DS1 is operating at minimum temperature (-15 °C), the pressure could drop to a value able to trigger the warning level. However, functionality at the DS1 pressure warning level is fully ensured. The device stops operating at blocking pressure.

Relative Humidity 93%

DS1 has been designed to work in indoors where the relative humidity is high.

The design technique includes conformal coating of all electronic boards inside the control system.

In addition, vertical positioning of the electronic components is another important feature with regard to humidity during operation.

The apparatus has been tested for up to 93% relative humidity both when it is operating and not operating.

However, as in every indoor device, to prevent condensation from forming, rapid temperature changes should be mitigated in particular cases where the temperature drops very quickly in conjunction with high relative humidity. This precaution must always be considered when MV applications are present, because condensation may form in any part of the compartment. Lastly, pre-conditioning in a controlled environment should be performed before using DS1 when it has been stored for a long period in an uncontrolled environment.

Altitude <1000 m

2.5 Apparatus operating instructions



DS1 capacitor switches ensure a minimum degree of protection (IP2X) if installed in the following conditions:

- fixed version, with protective netting.

Under these conditions, the operator is protected against accidental contact with moving parts.

Take care of moving parts if mechanical operations are performed on the apparatus with the protective netting removed. After the mechanical and movement operations have been completed, remember to remove the protection net before energizing the MV bus bars.

If the operations are obstructed, do not force the mechanical interlocks but check that the operation sequence is correct (refer to the Installation Guidelines section).

2.6 Description of the capacitor-switch closing and opening operations

The apparatus can only be operated electrically. Manual operation is NOT allowed.

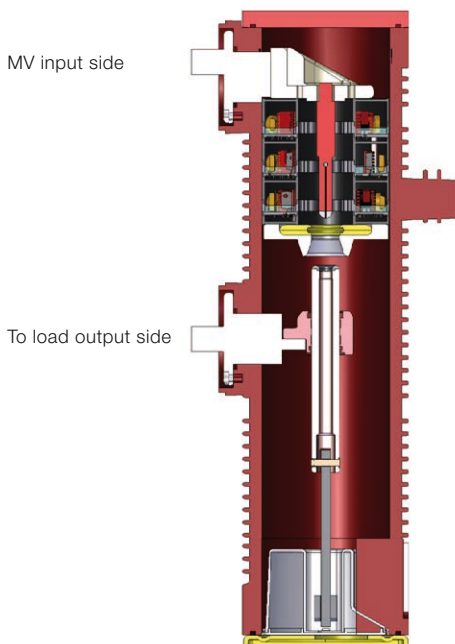
A new capacitor switch concept has been developed by combining of a mechanical contact system and diodes. The mechanical contact system is operated by a servomotor controlled by a drive unit. The pole switch is illustrated in Figure 2, which shows the cross section of a power part and relative kinematic chain.



IMPORTANT

The Input and Load (output) sides must not be inverted.

DS1 must not be assembled upside down.



Note:
The illustration is indicative and not binding. We reserve the right to make changes without notice in the course of technical development of the product.

Figure 6. Section of DS1 power part

By turning the drive shaft through approx. 140 degrees, the power contacts will change from the closed to the open state while the reverse movement will close them again.

The purpose of the device is to connect and disconnect the capacitor bank in conjunction with a precise motion profile and reliable synchronization.

Transitory commutation is performed by power diodes without an arc during opening and inrush during closing.

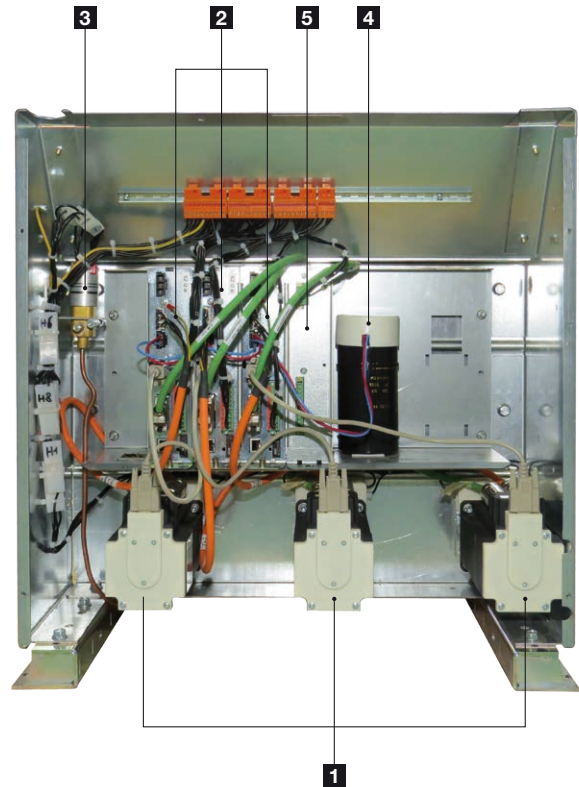


Figure 7. Internal layout of DS1

1. Independent servo motors
2. Control unit for each phase:
 - a. Synchronization
 - b. Actuation
 - c. System diagnostics
 - d. Micro Motion Control
3. Dry air pressure sensor
4. Operation capacitor
5. Power supply unit

Note: The illustration is indicative and not binding.

We reserve the right to make changes without notice in the course of technical development of the product.

A specific real-time control completes the three-phase system. The system is fully integrated inside the DS1 and complete diagnostics of the three-phase system application has been developed.

2.7 DS1 Closing and Opening switching behaviour

DS1 performs synchronous switching with the control system constantly engaged with the upstream voltage reference. To do this, the signal from a voltage divider (mandatory phase to ground on phase R) is detected by its control system.

When an Open command or Close command is transmitted to DS1, switching is performed by the control system using network synchronization and not the command as the trigger.

In addition to this feature, a precise ability to coordinate three-phase system movement and diode technology achieve very performance-oriented switching capability without significant inrush, AC voltage distortions or high frequency disturbance, as well as precise zero crossing current cut-off.

Typical DS1 switching behaviour is outlined below, where main circuit making and breaking possess the characteristics described above since DS1 contains the diode that naturally makes and breaks the current.

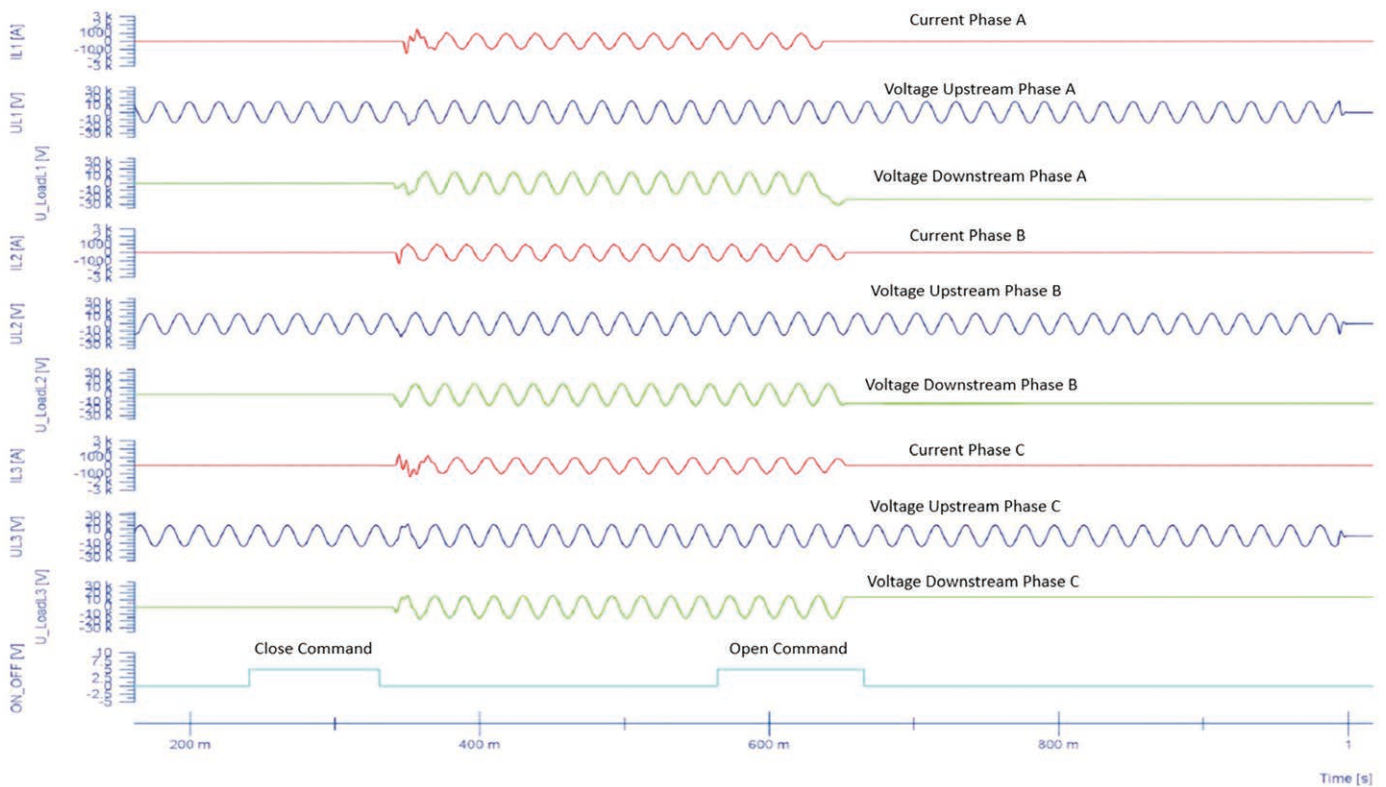


Figure 8. DS1 behaviour during a power test at 17.5kV 630A

3. Description of the control and supply electrical interface

3.1 Power Supply Characteristics

The DS1 power supply characteristics are:

Parameter	Symbol	Value	Unit
Vaux – Voltage input range	Vaux Vin	93 to 300	V _{DC}
Vaux – Max (active) power consumption	Vaux P _{MAX}	150	W
Vaux – Max current consumption		2,5	A _{RMS}
Vaux – Maximum VA consumption		220	VA
Vaux – Inrush limiter (peak current)	Vaux I _{LIM}	2	A _{PEAK}

Table 1. Auxiliary supply input characteristics

3.2 Description of the DS1 output

DS1 provides the following 3 outputs, depending on the switch status:

- Ready (dry contact closed when DS1 is ready to operate).
- Watchdog (solid-state output blinks to indicate that DS1 is energized and processing its functions).
- Alarm (dry contact closed when DS1 shows functions in a faulty way during operations)

Consult Outputs/Inputs in the following sections for more details about the DS1 outputs.

Additional outputs are installed in the device so as to monitor the internal pressure status as follows:

- Pressure OK (Output is high (+VSupply) when pressure is OK)
- Pressure Warning (Output is high (+VSupply) when pressure is below a first threshold)
- Pressure Low (Output is high (+VSupply) when pressure is below a blocking threshold)

DS1 Position Sensing indication (Close/Open).

Closed (dry contact is closed when DS1 is in the closed position).

Opened (dry contact is closed when DS1 is in the open position).

3.3 Electrical characteristics of the outputs

The **Ready and Alarm outputs** are AC/DC insulated outputs (dry contact).

Their electrical characteristics are illustrated in the graph below. Compliance with the current rating is mandatory so as to prevent damage to the dry contact.

The contact data and maximum DC load breaking capacity are indicated in the table and graph below.

Contact data	
Contact configuration	Watch-Dog NC, others NO
Contact set	single contact
Type of interruption	micro disconnection
Rated current	6 A
Rated voltage / max switching voltage AC	240/400 VAC
Maximum breaking capacity AC	1500 VA
Limiting making capacity, max 4 s, duty factor 10%	10 A

Figure 9. Ready and Alarm aux contact electrical ratings

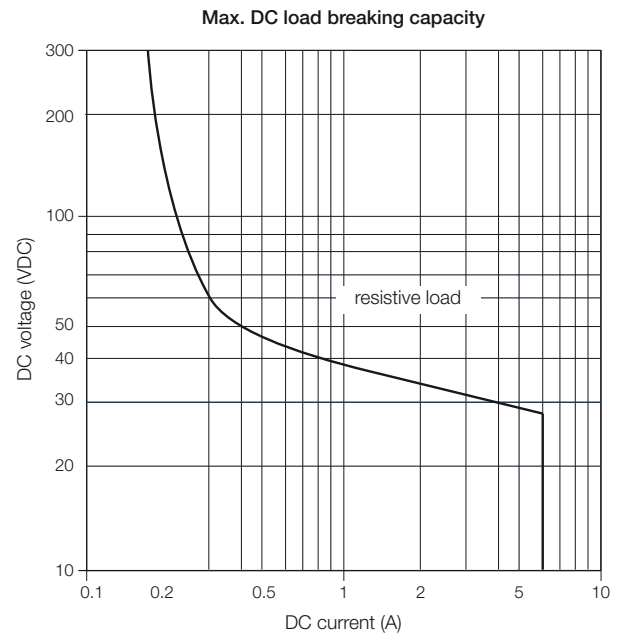


Figure 10. DC load break capacity of Ready and Alarm contacts

If the installation requires higher current, an auxiliary relay can be used in order to replicate the contact and perform higher current capability.

The **Watchdog Output** is a solid-state output that blinks in order to verify system integrity, including monitoring of SW running inside the device.

Since this kind of output is continuously turning on/off (every 0.2 Sec), replication of this function by a mechanical relay with higher current is not recommended.

The electrical characteristics of the Watchdog output are given below.

Characteristics	Recommended Operating Conditions
Supply Voltage	250 VDC/AC
On-state current I _{ON}	<100mA
Operating Temperature	-20 °C +65 °C

Table 2. Watchdog output characteristics

Pressure Monitoring is performed by a pressure switch with two thresholds: 4.1 bar (absolute) and 3.7 bar (absolute)
The maximum absolute ratings for the contacts are:

Voltage	Resistive Load (cos(fi)=1)	Inductive Load (cos(fi)=0.6 – 0.7)
125 VAC	3A	2A
250 VAC	3A	2A
30 VDC	3A	2A
125 VDC	0.4A	0.05A

Table 3. Pressure sensor output characteristics

Note: In the DC current condition the time constant must be less than 7ms for inductive loads.

DS1 Position Sensing the (Close/Open) indication is given by dry contacts.

The recommended operating conditions are summarized below:

Position Switch Electrical Characteristics

Rated Insulation Voltage	AC 380V
Rated Operating Voltage	AC DC 250V
Rated Operating Current	AC 250V/16A; DC 250V/0.3A
Power Frequency withstand Voltage	2000 VAC
Contact Resistance	<=30mOhm

Table 4. Position Sensing output characteristics

If the installation requires higher current, an auxiliary relay can be used in order to replicate the contact and perform higher current capability.

3.4 Description of DS1 inputs

The following input signals can be transmitted to DS1 in order to provide the required operations.

- **Open** (DS1 is requested to perform an Open operation when the switch is closed)
- **Close** (DS1 is requested to perform a Close operation when the switch is open)

Additional inputs are installed in order to provide additional control features as follows:

- **Interlock** (prevents DS1 from operating when the interlock loop is open)

The Interlock circuit is used by the control system logic to prevent operation when this circuit is open. The standard DS1 internal cabling opens the interlock circuit when the pressure reaches its minimum value. You are strongly advised to coordinate the interlock hierarchy according to substation interlock requirements (opening of the interlock loop when DS1 must be prevented from operating).

Since DS1 does not allow fault making and fault breaking events, you are also strongly advised to ensure safe coordination of the interlock circuit when:

- the upstream CB is operated (requested by control room OR protection fault TRIP)
- when the downstream earth switch is closed.

In both the above situations, you are strongly advised to coordinate the interlock function in order to open the interlock loop and prevent DS1 from operating.

3.5 Special INPUT-Only for commissioning and maintenance

A special input is installed for the purpose of providing special control features:

Upstream CB Interlock



The upstream CB Interlock is an input that is only used for maintenance or commissioning. Excitation allows DS1 to operate without synchronization in order to perform CO sequences without MV power on the bus bars.

Excitation of this input when MV is supplied is absolutely forbidden since DS1 will operate without synchronization and its integrity could be compromised.

Please refer to the commissioning procedure for details.

Special inputs are installed in order to provide special control features during commissioning or maintenance.

Homing

DS1 only controls the position of the power part when this is, within certain limits, in the Closed or Open Condition. A Homing command can be provided when, during maintenance or commissioning, the position of the switch is not in the Open or Closed position. DS1 will process the request and initialize its position in the Open condition. The homing command is only processed when the upstream CB Interlock is provided (the MV bus bar are de-energized).

Reset

DS1 is equipped with an advanced diagnostic runtime. Its status is continuously monitored both when DS1 is Idle (operating condition waiting for a command) and operating.

When an alarm event TRIPS (something wrong has happened during operation), DS1 completes the requested operation and then sets to the Alarm status.

If this occurs, it is advisable to stop all operations and call ABB's representative for assistance.



When a reset command is given, DS1 resets the alarm and returns to its operating state. This operation can only take place if DS1 has been de-energized.
 Is strictly forbidden to reset an Alarm that occurs when DS1 is in service in order to enable it to become operative again.
 ABB declines all liability for the DS1 following failure to comply with this rule.

Note: DS1 is equipped with an internal event recorder that records all the events and operations the switch is requested to perform. ABB's service technician can detect any misuse of the reset, homing and upstream CB functions.

The warranty and ABB's liability for the DS1 will become void following misuse of the special input.



IMPORTANT
 Operators who manage the DS1 must be informed that use of the upstream CB Interlock (maintenance mode) when the switch is energized by MV can result in serious malfunctioning of the entire apparatus.

3.6 Electrical characteristics of the INPUT

The DS1 input electrical characteristics are summarized in the table below:

Description	Activation Voltage	Average Power Required	Reaction time
Open	24 VDC	5W	20 ms
Close	24 VDC	5W	20 ms
Interlock	24 VDC	<1W	1 sec
Reset	24 VDC	5W	20 ms
Homing	24 VDC	5W	20 ms
UP STREAM CB	24 VDC	<1W	1 sec

Table 5. DS1 - Description of the input

3.7 Input Acceptance Logic

When the system is ready to operate, the Input Acceptance Logic is as follows:

- Level-triggered Open Trip command
- Edge-triggered Close Trip

Consult the detailed functional description and diagnostics section for a description of the condition that enables operation.

3.8 DS1 functional descriptions

DS1 performs synchronous switching with the control system constantly engaged with the upstream voltage reference. To achieve this, the signal from a voltage divider (mandatory phase to ground on phase R) is detected by its control system. When commissioning has terminated, DS1 is ready to operate 2-3 seconds after its control system has measured the AC voltage reference (the Ready relay is closed at this stage).

- **Close** command, DS1 closes the circuit.
- **Open** command, DS1 opens the circuit.

Open/Close are accomplished by synchronizing the movement of the power part in order to energize and de-energize the power capacitor bank with the internal power diode when requested by the substation.

In addition to its main function, DS1 is equipped with a powerful diagnostics able to identify internal faults (motor, control system, etc.) in the system before the operation.

Ready Output OFF (Not ready Condition)

The switch is not ready to operate. This situation:

- can be temporary at power up (for the time required by the DS1 Control System to charge the main capacitor and perform system diagnostics);
- can occur when upstream voltage is not present;
- can occur when the interlock circuit has been opened;
- can occur when the time required for the MV capacitor bank to discharge after an Open operation has not elapsed (DS1 allows a configurable time to discharge the MV capacitor bank by applying a mask on close command-close command inhibition).

Standard Close command inhibition is 5 minutes. DS1 applies the same Close command inhibition setting at startup. Please contact ABB for special close command inhibition times or to bypass this function;

- can occur when the control system is overheated (automatically recovered when the temperature returns below a tripping threshold). The maximum admissible operating temperature for DS1 (external to the switch) is +55 °C;
- can be due to internal diagnostic faults (e.g. communication lost between the three controls, incorrect internal voltage power rails, or encoder coherence test not passed). All the internal diagnostic faults automatically recover when the system re-acquires full functionality.

Alarm Output ON (Alarm Condition)

The alarm status of the switch will be provided by a clean contact that is normally open when the switch is fully operating. This contact will be closed by the DS1 control system when a faulty condition is detected. An alarm status also implies Ready output OFF (Not Ready Condition)

- **Ready ON:** the switch is fully operating. The dry contact of the ready status is closed. Installation of a lamp (conforming to the current capability of the contact) is recommended. The lamp (or the contact) will be OFF (or open) if a faulty condition occurs and prevents synchronized switching.

Note: When the system is not energized, the ready status will be OFF due to absence of the MV sensor signal allowing switching synchronization. When the system is energized with at least 1.5 kV rms (at the suggested voltage divider) and the frequency range is within the nominal +/- 1.4 Hz value, variation within this range is fully accepted and compensated by the control system setting to the ready condition (Ready ON).

- **Watchdog Green (solid-state output) OR Lamp ON:** the system shows that it is fully alive. The watchdog is internal hardware circuitry that constantly checks the integrity of the system and ensures that the software is running properly. The watchdog signal will be OFF when a faulty switch status that could be caused by a hardware problem is present.
- **Alarm ON.** The dry contact of the alarm status is closed. Installation of a lamp (conforming to the current capability of the contact) is recommended. Alarm ON indicates a fault concerning power part positioning OR a response to internal diagnostics, as described below:
 - Incorrect positioning at startup (which can be adjusted by means of the commissioning procedure described below (only feasible in a de-energized condition))
 - Bad behaviour during actuations (can be adjusted by means of the commissioning procedure but only feasible in a de-energized condition and only by qualified ABB personnel)
 - Bad response to the Micro Motion self-check (can be adjusted by means of the commissioning procedure but only feasible in a de-energized condition and only by qualified ABB personnel)

Note: the Micro Motion Test is self-executed by the system when 24 hours have elapsed without operation with the system in the closed position. This diagnostic check produces a negligible movement of the power part but is sufficient to allow the system to check the actuators, power part response and feedback coherence of the redundant position sensing built in the system.

4. DS1 Diagnostics

DS1 is equipped with internal powerful diagnostics system able to identify system faults and increase the reliability of operations in the network.

The following diagram illustrates the diagnostic hierarchy attached below the system architecture of DS1:

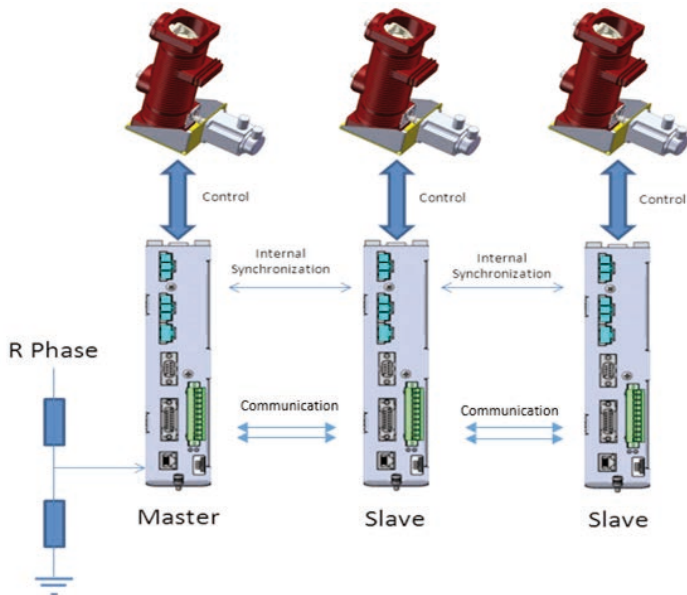


Figure 11. DS1 system architecture

Part of the diagnostics concerns the individual subsystem and is performed individually (eg. each unit with its circuits, motors etc.).

In addition to subsystem diagnostics, DS1 includes System diagnostics concerning the status of the whole apparatus.

DS1 performs an operation by only applying an Open or Close command when the master system (system diagnostics) is in the READY condition.

4.1 Base Module Diagnostics

Startup Diagnostics for all subsystems

At power up, the first step is to check communication start-up in the three-phase system (integrity of CPU and versions is checked).

When this step has terminated, the green led of the three control subsystems starts blinking fast.

The capacitor charger starts charging capacitor storage at 350 VDC.

After this step, all the following functionalities are continuously checked by every subsystem as follows:

- Internal power rails.
- Internal temperatures.
- Encoder.
- Motor port Integrity.
- Motor connections and motor winding integrity.

- Tank capacity estimation

This operation is performed by each module at a time since capacitor excitation performed by just one module can disturb the measurement performed by another one.

- Pole position check

If the position is within certain limits (almost Open or Closed), the subsystem adjusts the position (see shaft supervision monitoring function). If the position is too far from the Open or Closed position the system stops and requires a Homing procedure to restore it to the Open condition.

If one of the three positions is wrong, the red led will be on for the entire unit (the shaft supervision function is blocking all the modules).

If the pole positions are ok and other diagnostics checks are performed successfully, the units will be ready to operate (the red led on the control system will now turn off), with the exception of the Master system unit.

The Master system not only allows the individual subsystem diagnostics to operate but the System Diagnostics as well.

Position Supervision Function

The motion controller turn off (sleep status) in order to reduce power consumption and power dissipation. An additional supervision function continuously checks the position of the shaft and wakes up the motion controller if a significant movement is detected. At this point, the motion controller block reacts immediately and corrects the shaft position.

Master Diagnostics at startup

At this stage, the Master is not providing the ready condition because other steps are still required:

The Ready condition is inhibited at startup (if the device is in the Open condition).

DS1 implements an internal timer (default is 5 mins) that prevents closing after opening since the power capacitors are not discharged.

Note that in a de-energized condition (upstream CB input high) the close mask function (close inhibition) is by-passed.

Contact your ABB representative support or sales to request removal or a customized version of the "close inhibition time" function. (It can be programmed in the control system).

4.2 Master Diagnostics

The Ready condition can be inhibited at any time by a subsystem that is preventing operation due to failed subsystem diagnostic steps.

The Ready condition is inhibited by the master due to an absent synchronization signal (in the operative mode without the upstream CB input energized).

The Ready condition is inhibited if low pressure (blocking the pressure sensor) opens the interlock loop (see circuit diagrams).

The Ready Condition is inhibited when the position supervisor is tripping.

4.3 Synchronization Diagnostics

Synchronization Diagnostics frequency variations from the nominal value are automatically accepted and compensated if:

$(Nominal\ Frequency - 1.4\ Hz) < Frequency\ measured < (Nominal\ Frequency + 1.4\ Hz)$

Synchronization Diagnostics inhibit the Ready condition when the signal from the voltage sensor is less than 100mV (corresponding to 1.7 kV on the bus bars).

Synchronization Diagnostics inhibit the Ready condition when the harmonic content is too high.

Synchronization diagnostics cannot detect an imbalance between the three-phase systems and cannot prevent an operation if this imbalance leads to a significant error in power contact timing.

An additional protection to prevent this type of operation should be installed in the up-stream CB or in the system.

4.4 Diagnostics Table

DS1			Pressure Sensor			Description	Actions
Status	Ready	Alarm	OK	Warning	Low		
OPEN	Ready	-	OK	-	-	DS1 is ready to perform a close operation.	-
OPEN	Ready	-	-	Warning	-	DS1 is ready to perform a close operation. Check 'Actions'.	Check pressure level. If it is not ok, plan a refill. If it is ok and the Warning signal persists, contact ABB and plan a check. DS1 can still perform a close and open operation.
OPEN	-	-	OK	-	-	DS1 is not ready to perform a close operation. Check 'Actions'.	This condition occurs when there is no voltage on busbar side, at start up or when the Interlock loop is open. DS1 can perform open and close operations by providing power to Upstream CB interlock input. If this condition occurs when voltage is present on busbar side, check the interlock loop. If it is closed, contact ABB and plan a check.
OPEN	-	-	-	Warning	Low	DS1 is not ready to perform a close operation. Check 'Actions'.	Check pressure level. If it is not ok, plan a refill. If it is ok and this condition persists, contact ABB and plan a check.
OPEN	-	ALARM	OK	-	-	DS1 is not ready to perform a close operation.	DS1 reached the final position after an open operation, but an anomaly was detected during the operation. Contact ABB and plan a check.
Incoherent	-	ALARM	OK	-	-	DS1 is not ready to perform a close operation. DS1 is in alarm mode. Check 'Actions'.	Pole position is not coherent. Contact ABB and plan a check.
CLOSE	Ready	-	OK	-	-	DS1 is ready to perform a close operation.	-
CLOSE	Ready	-	-	Warning	-	DS1 is ready to perform a close operation. Check 'Actions'.	Check pressure level. If it is not ok, plan a refill. If it is ok and the Warning signal persists, contact ABB and plan a check. DS1 can still perform a close and open operation.
CLOSE	-	-	OK	-	-	DS1 is not ready to perform a close operation. Check 'Actions'.	This condition occurs when there is no voltage on busbar side. at start up or when the Interlock loop is open. DS1 can perform open and close operations by providing power to Upstream CB interlock input. If this condition occurs when voltage is present on busbar side, check the interlock loop. If it is closed, contact ABB and plan a check.
CLOSE	-	-	-	Warning	Low	DS1 is not ready to perform a close operation. Check 'Actions'.	Check pressure level. If it is not ok, plan a refill. If it is ok and this condition persists, contact ABB and plan a check.
CLOSE	-	ALARM	OK	-	-	DS1 is not ready to perform a close operation. DS1 is in alarm mode. Check 'Actions'.	DS1 reached the final position after a close operation, but an anomaly was detected during the operation. Contact ABB and plan a check.

Figure 12. DS1 Diagnostic indications

5. Installation Guideline

5.1 General



Correct installation is of prime importance. The instructions given by the manufacturer must be carefully studied and followed. It is good practice to wear gloves to handle the parts during installation.

All the safety recommendations at the beginning of the document must be complied with during installation and commissioning.

5.2 Before installing the apparatus

Please refer to all installation requirements as indicated in product catalogue.

IMPORTANT: Check the sense of rotation in the power plant before installing a DS1.

Effectiveness of the diode method depends on the correct sense of rotation setup of the MV Power Bus Bars.

DS1 is designed for a direct sense of rotation (R, S, T or A, B, C in time domain). Swap the S (or B) and T (or C) phases with each other if the sense of rotation in the installation is in reverse.



Figure 13. Identification of DS1 phases

5.3 Installation requirements

Indoor

The design of the DS1 makes the synchronous switch suitable for indoor applications.

Harmonic distortion on voltage

The DS1 can perform synchronous operations even with high values of total harmonic distortion on voltage (THDV). However, this value must not be such that it will cause multiple zero-crossing of the voltage waveform.

Rated frequency

The DS1 can perform synchronous operations even when the power frequency is subject to variations compared to the rated value, by automatically adjusting its actuation time. Such variations must not, however, exceed ± 1.4 Hz.

Ungrounded capacitor banks

The synchronization signal acquisition logic of the DS1 is suitable for operating only on capacitor banks. These capacitors must have an ungrounded centre of the star.

In case of retrofit on an existing capacitor bank with inrush reactors, such reactors must be eliminated or the DS1 must be electrically located downstream with respect to them.

Capacitor discharge

When a capacitor bank is disconnected from the network, the capacitor units remain charged to the voltage at which they are disconnected. These must therefore be discharged to a voltage value less than or equal to 50 V within 5 minutes, before being connected again, according to the standard IEEE C37.99.

To prevent reclosing before the capacitors are discharged, once the opening operation has been performed, the DS1 closing command is inhibited for 5 minutes by the control unit, thus ensuring that it is impossible to perform closing operations on the charged capacitor banks.

The DS1 can perform the following operational sequence:

C – 300 ms – O – 5 min – C

Contact ABB if the inhibition time needs to be changed.

In any case, the closing of a non-discharged bank must never be carried out with DS1.

Voltage sensor

The DS1 requires the measurement of busbar voltage on phase R (A) by means of a voltage sensor. Only one sensor is needed, since the load is symmetrical (floating star centre) and purely capacitive.

DS1 has been tested and certified with the ABB KEVA 24 A3 sensor. ABB recommends the use of an ABB KEVA 24 A3 sensor or equivalent.

The ABB KEVA 24 A3 sensor is not included in the DS1.

Direct phase rotation

The logic on which the opening and closing operations are based requires the sequence of the primary three-phase power supply network to follow the direct phase rotation R, S, T (A, B, C).

Fault-making

The DS1 cannot perform a fault-making operation. For this reason, the DS1 must be properly integrated into the system so as to minimize the likelihood and impact of this event.

If necessary, contact ABB to get technical support to assess these requirements.

5.4 Installation of fixed apparatus



You are strongly advised to use type-approved compartments able to hold the internal arc in case of failure because the apparatus is not designed to meet any safety requirements in the event of faults.

The apparatus can be mounted directly on the supporting frames provided by the customer.

The areas on which the supporting frames are mounted must be on the same horizontal plane to avoid any risk of distortion in the breaker frame.

Do not install the apparatus without providing a sound support on which to fix the DS1 base mainframe. Failure to do this can lead to serious malfunctions in the apparatus.

Fit the isolating partitions if provided.

A minimum degree of protection (IP2X) must be guaranteed from the front towards live parts.

Comply with the following recommendation when DS1 is integrated into a compartment.

Refer to the official overall dimensions (ANNEX B) for positioning in the compartment and use the base of the device to provide support.

5.5 Additional installation recommendations

Comply with the following recommendations when DS1 is integrated into a metal-enclosed system:

- Refer to the official external drawings provided by the ABB sales representative for positioning in the compartment and use the base of the device to provide support. An example is enclosed at the end of the document (Annex B).

- **Do not install the apparatus without providing a sound support on which to fix the DS1 base mainframe.** DS1 weighs about 130 kg and during the switching process it will produce significant vertical oscillations. An unsecure support can lead to excessive stress on the power contact when connected to MV bus bars.

This can cause serious malfunctions in the apparatus and also create problems involving the fastening components of the bus bars in the compartment (e.g. bushings, etc).

- **It is forbidden to reverse the supply side with the load side.**
- **It is forbidden to install DS1 upside down.**

5.6 Preliminary operations



It is advisable to use type-approved compartments able to hold the internal arc in case of failure because the apparatus is not designed to meet any safety requirements in the event of faults.

Clean the insulating parts with a clean dry rag and check that the upper and lower terminals are clean and free from deformation caused by shocks received during transport or storage.

The apparatus can be mounted directly on the supporting frames. The supporting frames must be on the same horizontal plane to prevent the switch frame from becoming distorted.

Do not install the apparatus without providing a sound support on which to fix the DS1 base mainframe.

The anchoring holes are drilled in the lower part of the frame. Fit the isolating partitions if provided.

A minimum degree of protection (IP2X) must be guaranteed from the front towards live parts.

6. Fixed Apparatus power circuit connections

6.1 General directions

Make the connections using only the square terminals supplied with the apparatus.

Select the conductor cross-section according to the operating and short-circuit current of the installation.

Suitable supporting insulators sized to suit the electrodynamic stress that may be produced by the short-circuit current of the installation must be provided near the terminals of the fixed version apparatus or enclosure.

6.2 Mounting the connections

Check that the connection contact surfaces are perfectly flat and free from burrs, traces of oxidation or deformation due to drilling or impact.

Perform the operations described in the table on the contact surface of the conductor, depending on the conductive material and surface treatment used.

6.3 Mounting procedures

Place the connections in contact with the apparatus terminals. Fit a spring washer and a flat washer between the head of the bolt and the connection.

Tighten the bolt, taking care not to subject the insulating parts to stress (see table-tightening torque).

Make sure that the connections do not exert force on the terminals.

In the case of cable connections, carefully comply with the manufacturer's instructions for terminating the cables.

Bare copper	Silver-plated copper or aluminium	Bare aluminium
Clean with a fine file or emery cloth	Clean with a rough dry rag	Clean with a metallic brush or emery cloth
Fully tighten and smear a film of industrial vaseline grease over the contact surfaces	In case of tough oxidation traces only, clean with a very fine emery cloth, taking care not to remove the surface layer	Immediately smear a film of industrial vaseline grease over the contact surfaces
Interpose the copper-aluminium bi-metal with restored surfaces between the aluminium connection and the copper terminal (copper side in contact with the terminal; aluminium side in contact with the connection)	If necessary, recondition the surface treatment	



Figure 14. DS1 power connections

Table of tightening torque

Screw	Tightening torque
M6	10 Nm
M8	30 Nm
M10	40 Nm
M12	70 Nm

6.4 Three-phase power line connections

The DS1 main connection layout can be summarized as follows:

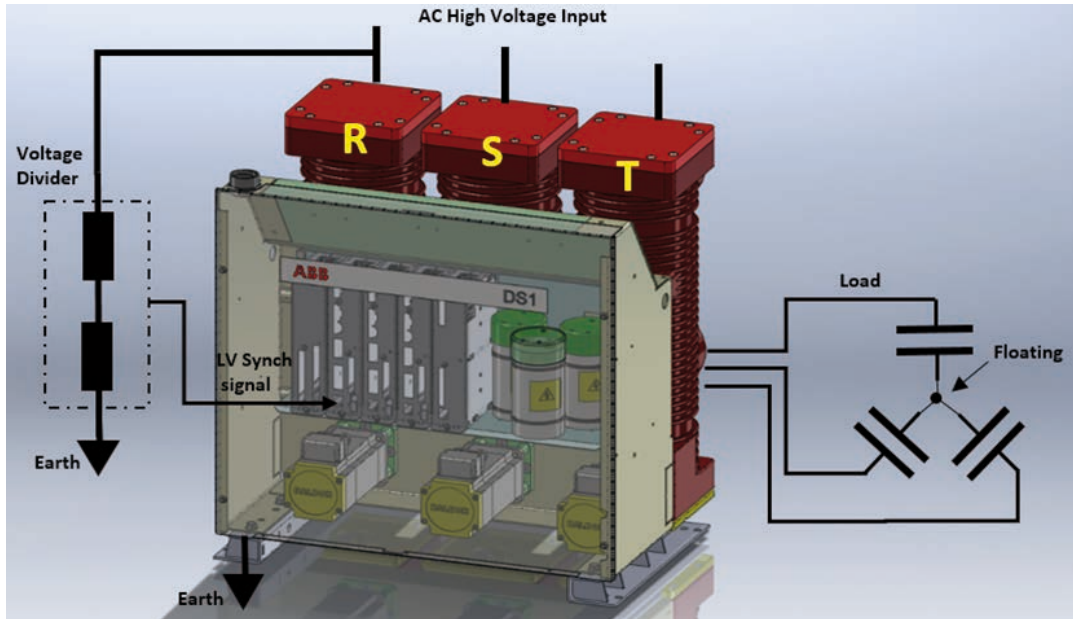


Figure 15. DS1 main connection layout



Connect the six-power pole terminations to the high voltage bars of the substation. The three upper terminals are the input power connections while the three lower terminals are the output power connections (to capacitive load). Take care to comply with the correct sense of rotation (R-S-T) as indicated in the previous section.

6.5 Load connection



The only permissible load configuration for DS1 is:

- capacitive load,
- three phases, STAR configuration
- **NEUTRAL POINT NOT CONNECTED TO GROUND.**

No other configurations are allowed.



The capacitor bank (the load) must be connected directly to the output terminal of DS1.

No inrush reactors are allowed between DS1 and the load.

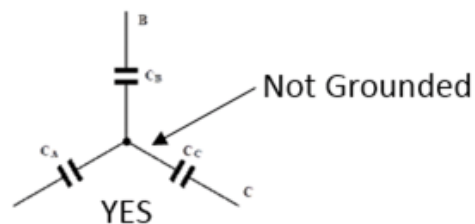
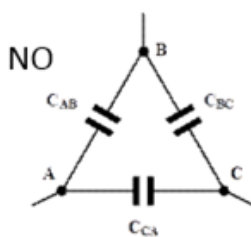


Figure 16. Permissible load configuration

6.6 Synchronization sensor

A resistive voltage divider must be connected to the unit in order to transmit a correct synchronization voltage signal to the control unit. The voltage sensor must be installed upstream of the DS1 switch and connected to phase R.

The resistive divider is used for its linearity characteristics (the output voltage is directly proportional to the input voltage).

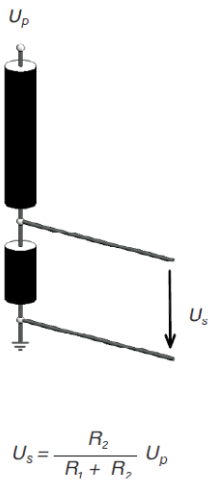


Figure 17. Voltage divider principle

The following characteristics are required:

Highest voltage for equipment	24	kV
Rated power frequency test voltage	50	kV
Rated lightning impulse test voltage	125	kV
Rated primary voltage	22/√3	kV

The standard model is the KEVA sensor by ABB. The voltage reduction ratio is 1:10000.

You are strongly advised to use ABB's Keva sensor. This was the sensor used for **testing DS1**. If a different sensor is used, the voltage output must not exceed 1.2 V_{pp}.

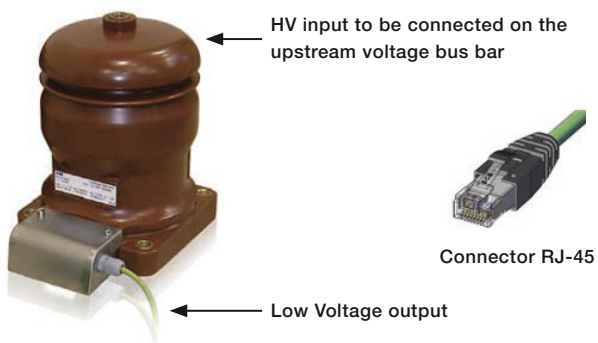
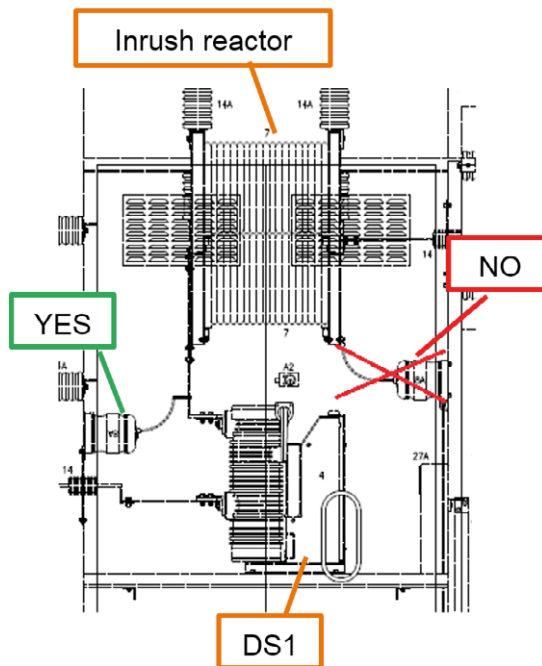


Figure 18. KEVA 24 A3 voltage divider



Wiring of the Keva sensor.

If there is an inrush reactor in the circuit, make sure that the Keva sensor is wired directly to the input terminal of DS1, after the inrush reactor itself.



IMPORTANT

Install the voltage sensor by connecting it to phase R upstream. All other connections are forbidden. Switching timing is built into the control system program.

Install the voltage sensor with a clean layout in the compartment. Comply with the required insulation clearance, the shape of the connections (rounded) and use screws with round shapes.

Make sure that the GROUND of the sensor is effective. Take care of the paint in the compartment, since it can produce insulation and compromise sensor grounding. The 4 holes at the base of the sensor provide the grounding function. Remove the paint or add an additional cord in at least one of the holes in the compartment.



Make sure that the layout of the low voltage output of the sensor is clean. Keep it as far as possible from the live bus bars and use all the available metal ducts. If none of the ducts is available, install an additional duct (always respecting the insulation clearance from the bus bars. Even if the sensor cable is shielded is always a good rule to provide proper protection for the LV equipment.

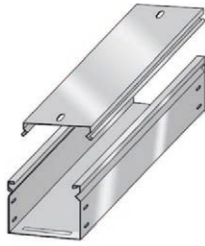


Figure 19. Example of a metal duct to shield the synchronization LV cable from the MV supply

Connect the RJ45 connector to the specific input in the control system as shown below:

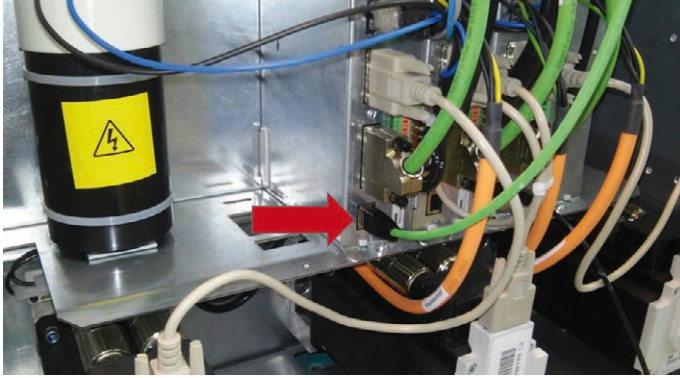


Figure 20. RJ45 input for synchronization

6.7 Voltage Sensor Connections

The HV input of the voltage sensor must be connected to phase R on the input side of capacitor switch (upper terminals of poles), because it must detect the AC voltage when the capacitor switch is both Open and Closed.

Make sure you make a good GND connection by fixing the sensor by the four holes in the base of the unit to an electrically grounded metallic surface.

The Low Voltage output will be connected to the master unit of ACU by means of an 8-pole RJ 45 connector.

Terminals 7 and 8 are the pins used:

7 = Active pole

8 = Return (GND)

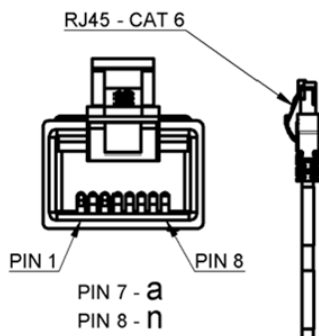


Figure 21. Pin-out of the Keva sensor connector

Insert, into XK2, the RJ connector from the voltage divider used for synchronization purposes.

6.8 Earthing



Use the screw marked with the relative symbol to earth the fixed version of the apparatus.

Clean and degrease an area about 30 mm in diameter all around. Cover the entire joint with vaseline after completing the assembly.

Use a conductor (bus bar or braid) with the cross-section indicated by the Standards in force.

6.9 Auxiliary circuit connection

The minimum cross-section of the wires used for the auxiliary circuits must not be less than that used for the internal wiring.

Fixed capacitor-switch terminal board connection

The auxiliary circuits of the capacitor-switch must be connected via the terminal board connection on the capacitor-switch structure.

Outside the capacitor-switch, the wires must be routed inside appropriately earthed metal tubes or ducts.

The wires for the commands, signals, statuses and alarms must be connected to the terminal boards as shown in the circuit diagram.

Connect the two power supply wires to the corresponding terminals on terminal boards 1 (+) and 2 (-).

Connect the green/yellow wire for the ground connection to terminal 7.

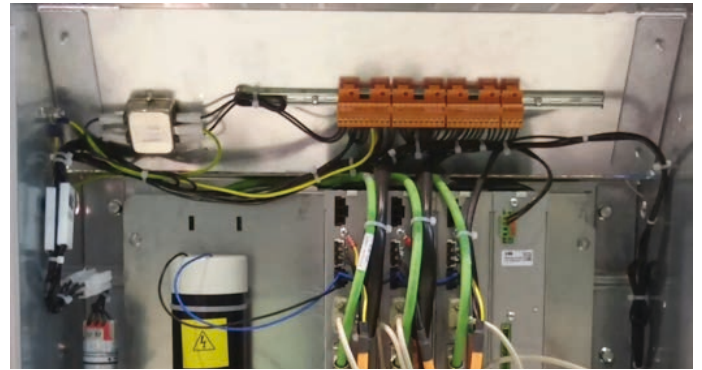


Figure 22. Terminal board

Refer to the terminal block of the auxiliary control circuit enclosed at the end of this document for all the electrical connections (see ANNEX A).

7. Commissioning

7.1 General procedures



All the commissioning operations must be carried out by ABB personnel or the customer's suitably qualified personnel with in-depth knowledge of the apparatus and installation.

If the operations are obstructed in some way, do not force the mechanical interlocks but check that the operating sequence is correct.

Perform the following operations before putting the apparatus into service:

- Make sure that the power connections to the apparatus terminals have been properly tightened;
- Make sure that the value of the supply voltage for the auxiliary circuits is within 85% and 110% of the rated voltage of the electrical devices;
- Check that there are no foreign bodies, such as packaging, between the moving parts;
- Check that air circulation in the apparatus installation site is adequate and that there is no danger of overheating.

Perform the inspections listed in the following table:

Subject of the Inspection	Procedure	Positive check
Insulation Resistance	Medium Voltage Circuits Using a 2500 V Megger, measure the insulation resistance between the phases and exposed conductive parts of the circuit	The isolation resistance should be at least 50MΩ and in any case, be constant over time
	Auxiliary Circuits Using a 500 V Megger (installed equipment permitting), measure the insulation resistance between the auxiliary circuits and the exposed conductive parts	The isolation resistance should be at least a few MΩ and in any case, be constant over time
Auxiliary Control Circuits	Make sure that the connections to the control circuits are correct. Supply the circuits	Normal switching and signaling
Maintenance Mode Operations	Perform closing and opening operations (see commissioning section)	The operations and relative signals occur correctly as indicated in the commissioning section
Auxiliary Circuits	Connect the auxiliary switch to suitable signaling circuits. Supply the circuit and perform closing and opening operations	Normal switching and signaling occur correctly

Table 6. General commissioning verifications

7.2 Startup and maintenance features

As shown in the electrical terminal block (ANNEX A) and described in the previous sections, DS1 provides a simple interface comprising the following binary input:

Upstream Circuit Breaker (CB) Interlock

Allows the switch to operate even if the system is not energized (and consequently not synchronized) by exciting the input.

Allows the Homing procedure to activate (the DS1 switch initializes its position in the Open condition).



Misuse of this function can prevent DS1 from functioning correctly (upstream Circuit Breaker (CB) Interlock not deactivated after commissioning).

ABB recommends coordination with an auxiliary switch indicating the CB status.

When the upstream Circuit Breaker status is provided directly by the operator, ABB recommends installation of a safety key lock. Key activation must be managed carefully because this operating option must only be used in the de-energized condition (during commissioning and maintenance).

ABB declines all liability for loss of system integrity due to misuse of the upstream CB interlock function.

Reset Push button

Can be used to reset a fault when this concerns system integrity or bad behavior during operations. The alarm led goes out when a reset is accepted by the system.

If the ready condition is not restored, the Homing command is required to recover full functionality.

Use of the Reset feature is not recommended when the system is energized without ABB's authorization, since when an Alarm Trip occurs, it means that faulty operation of the system has been detected during actuation.

Note: DS1 is equipped with an event recorder. This means that ABB is always able to detect misuse of this function.

Homing

Allows the position of the system to be initialized in the open position. The Homing procedure produces an effect when:

- the system is not in the open position
- a Reset command has been accepted by the system (the alarm lamp turns OFF after the Reset pushbutton has been pressed)
- upstream CB interlock feedback is enabled by the upstream CB Interlock status (or a Key Protected Command).

7.3 Pressure Monitoring

The DS1 capacitor switch has pressurized poles with dry air at 3.7 bar relative nominal pressure (53.66 PSI) at approximately 25 °C.

Note

The pressure inside the device depends on the temperature.

DS1 has been tested at minimum pressure.

Please note that if a fault occurs (temperature variation at the filling stage and tolerance of the pressure meter) when DS1 is operating at the minimum temperature (-15 °C), the pressure could drop to a value able to trigger the warning level.

However, functionality at the DS1 pressure warning level is fully ensured.

The device stops operating at blocking pressure.

It is equipped with a pressure sensor that connects all poles together.

A charging/discharging valve is installed inside the switch as shown below:



Figure 23. DS1 pressure sensor with its charging valve

7.4 Interface summary for Maintenance and Commissioning

The BI/BO outlined below allow full management of DS1:

- Open Binary Input
- Close Binary Input
- Interlock (loop made in the internal wiring of DS1)
- Reset Binary Input
- Homing Binary Input
- Upstream CB binary Input
- Pressure OK (active high contact from the pressure sensor)
- Pressure Warning (active high contact from the pressure sensor)
- Pressure Low (active high contact from the pressure sensor)
- Ready Output (Normally Open dry contact)
- Alarm Output (Normally Open dry contact)
- Watchdog Output (Blinking solid-state output)
- Open status Auxiliary contact
- Close status Auxiliary contact

All the BI must be stimulated and the status and position (Open/Close) of all the BO must be detected during DS1 commissioning and maintenance (Open/Close).

Alternatively, a small portable panel (ADD-ON control panel) can be used for commissioning, as shown in the example below:



Figure 24. Simple interface for early functional tests

R1		ACU supply voltage
15 kohm	2 W	110÷130 V
31 kohm	3 W	220÷250 V
6 kohm	1 W	24÷60 V

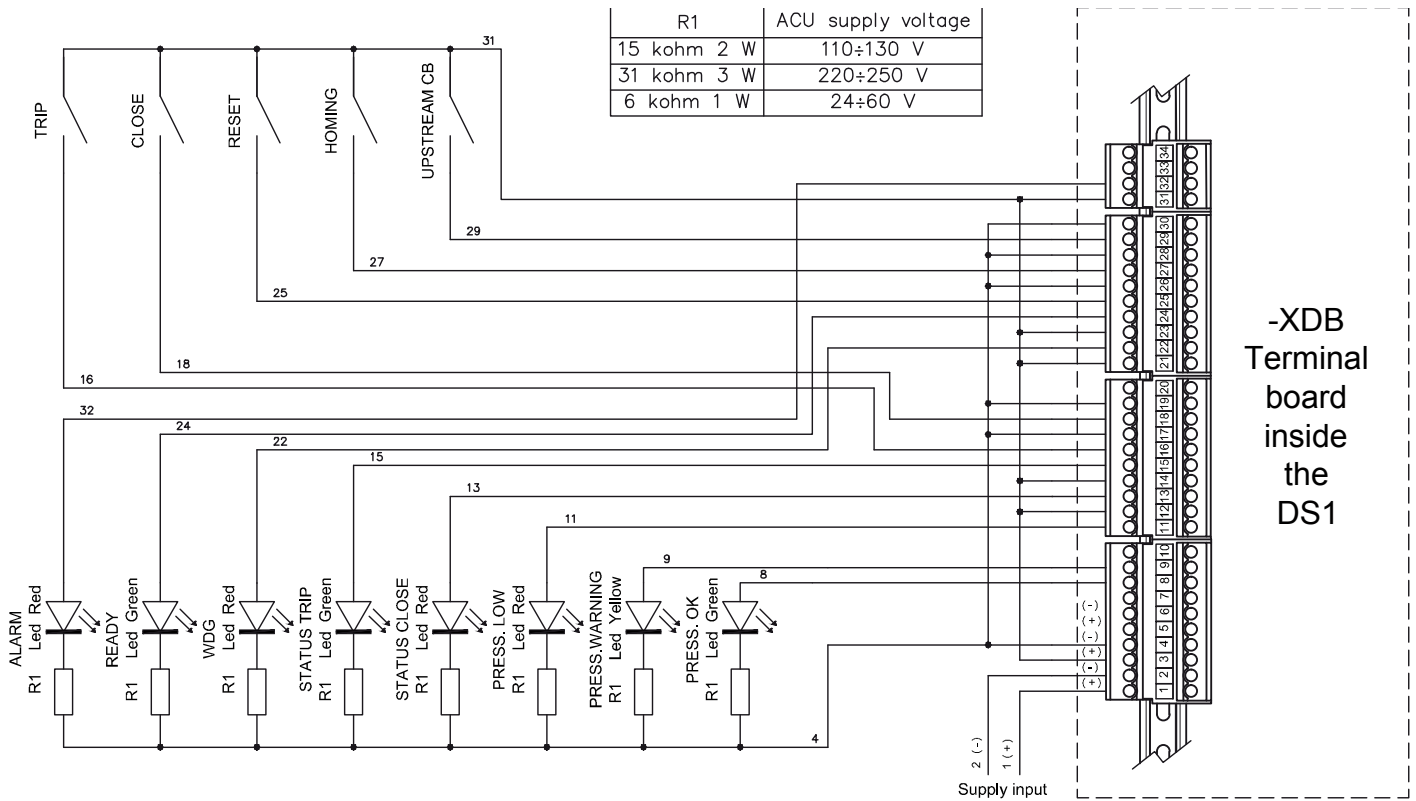



Figure 25. Example of an electrical interface

The wiring must be made in compliance with the official circuit diagram.

Once the wiring has been completed according to the DS1 auxiliary circuit diagram, use of pushbuttons and all the interfaces to be used for commissioning and maintenance will be available.



To prevent the Binary Output from being damaged, check the electrical characteristics of the contact before sizing lamp power consumption. If power consumption will be higher, a relay can be used to replicate the DS1 BO contact.

Use of an ADD-ON control panel can be helpful but wiring of DS1 to the remote control room and/or the LV compartment must be checked very carefully during the integration work to make sure that it is correct before the apparatus is put into service.

7.5 Commissioning - Test with no power, no sync

If the ADD-ON panel is used for integration and testing, remove all connectors with wires routed from the substation (commands, signals, status and alarms) from the terminal boards.

Connect the connectors of the ADD-ON control panel in the same corresponding positions.


The only connections that must remain are the two Power Supply wires (Terminal boards 1 (+) and 2 (-)). Make sure that terminals 10 and 20 are linked with a short wire so as to provide the Interlock command.

Install all the interlocks switches required to coordinate the power plant in order to obtain all the correct interlock hierarchy/levels. Take care of the interlock loop when the system is de-energized and or maintenance/commissioning must be performed (operations are inhibited when DS1 is opened).

Turn on the power supply

Wait a about 1 minute to allow the capacitor to reach a full charge.

DS1 requires additional time to fully check its integrity (board diagnostics, motor diagnostics and capacitor diagnostics).



Do not touch DS1 when it is supplied. Its internal capacitor storage reaches 350VDC and even if the wiring is insulated, the internal supply can represent an electrical hazard especially if the system functions in a faulty way.

The Key-switch on the ADD-ON control panel must remain in the CCW position (upstream CB binary input not excited).

The lamps on the ADD-ON control panel should be in following state:

P ok (green)	= ON
P warn (yellow)	= OFF
P low (red)	= OFF
WDG (green)	= ON (fast blinking)
Alarm (red)	= OFF
Ready (red)	= OFF

If an Alarm is ON, push the RESET button on the ADD-ON control panel.

The Key-switch on the ADD-ON control panel must be set to the CW position.

Give a HOMING command by pressing the relative pushbutton on the ADD-ON control panel.

The lamps on the ADD-ON control panel should now be in following states:

P ok (green)	= ON
P warn (yellow)	= OFF
P low (red)	= OFF
WDG (green)	= ON (fast blinking)
Alarm (red)	= OFF
Ready (red)	= ON

The switch is now ready to operate and by pressing the relative pushbutton on the ADD-ON control panel, it will be possible to perform Open and Close operations IN THE ABSENCE of an AC synchronization signal.

Attempt some C/O cycles.

The correct Open / Close status is reported to the ADD-ON control panel or to the remote monitoring utility of the substation.

Make sure that during fast actuation, DS1 is securely fixed to its support and that there are no significant vertical oscillations (otherwise, it means that the indications provided for positioning and fixing the apparatus in the compartment have not been followed correctly).



After re-connecting the substation wiring, check that after the power up sequence (1 minute is required), the system returns to the alive status but NOT in the READY CONDITION. This test allows you to make sure that the substation wiring does not excite the upstream CB interlock input due incorrect cabling.



Perform some Open/Close cycles and check that when the key switch is released (it will return automatically to the CCW position), the Ready indicator is OFF and the machine no longer operates. This test allows you to make sure that DS1 will not operate in the asynchronous mode when energized (as in the maintenance mode).

Lastly, perform an Open operation.

Turn off the power supply.

Wait at least 120 sec to allow the capacitor to completely discharge.

Disconnect and remove the ADD-ON control panel.

Fit the connectors wired to substation signals back into the terminal board again.

8. Periodical inspections

8.1 General

The capacitor-switch is maintenance free during normal service. The frequency and type of inspections required depend on the service conditions. Various factors must be taken into account: frequency of operations, interrupted current values, relative power factor and the installation ambient.

The following section includes an inspection chart showing the relevant time intervals.

As far as the time interval between these operations is concerned, it is advisable to comply with the specifications given in the table, at least during the first check. The optimal time limits for carrying out the following operations can be set according to the results obtained during the periodic inspections.

8.2 Checking program

After two years of field operation/or 2,000 CO electrical cycles check:

- DS1 CO functions with no power (see chapter on "Commissioning - Test with no power, no sync")
- System pressure
- Contact resistance (see chapter on "Measurement of resistance across closed contacts of poles").

If DS1 is installed in a polluted and aggressive ambient, it is advisable to check every year as described above. If DS1 is installed where a significant quantity of dust is present, clean all parts every year as preventive maintenance.

It is advisable to contact an ABB service center to have the apparatus checked after 5,000 electrical operations or 10 years. Every maintenance program must include the following operations:

- Check that all parts are free from built up dust, dirt, cracks and discharge traces in the following points:
- Check main bus bar screws tightening torque
- Check apparatus fixing screws tightening torque
- Remove the main cover and check the screws tightening torque for terminal board connection
- Check all the wiring inside DS1 and its integrity
- Check the synchronization cable.



IMPORTANT

To operate in full safety, all maintenance inspections must be performed with the system de-energized, the upstream supply in safe conditions and the downstream earth switch correctly connected. Compliance with all additional safety rules is also mandatory.

8.3 Measurement of air pressure inside poles

Connect a pressure gauge on the filling valve and measure the pressure inside the poles.

The value must be 4.7 ± 0.1 bar abs.

If value is lower, refill the poles up to their nominal pressure value with dry air, as indicated in the previous section.

8.4 Dry Air filling

DS1 is a pressurized switch filled with dry air. The factory fills DS1 with air possessing the following characteristics. Comply with the same characteristics when a filling operation is performed.

H ₂ O	< 2 ppm
CnHm	< 0.1 ppm
CO	< 1 ppm
CO ₂	< 0.2 ppm

8.5 Dry air filling procedure

- Cover the three poles with a protective net
- Using a kit similar to the one shown in the figure below, connect the pneumatic fast connector to the filling valve inlet.
- Open the main valve,
- Adjust the pressure limiter to about 5-6 bar
- Start filling.
- Increase the pressure up to the value of 4.7 bar absolute.



Figure 26. Filling equipment

The indications provided by the pressure sensor are:

Pressure OK

Pressure OK switch is closed: the operating pressure is higher than 3.1 Bar relative (44.961 PSI)

Pressure Warning

Pressure Warning switch is closed and Pressure OK switch is open: the pressure of the system is below 3.1 Bar relative.

The system is still operative in this condition. Refilling and inspection should be planned

Pressure Alarm

Red Lamp on: the pressure of the system is below 2.7 BAR relative (39.160 PSI). Operation is inhibited and the system is self-interlocked.

At this stage the interlock circuit of the DS1 control is opened. All operations are inhibited with the exception of the upstream CB breaker open condition (see commissioning and maintenance instructions).

8.6 Measurement of resistance across closed contacts of poles

Set the three poles in the Closed position. Refer to the “Commissioning - Test with no power, no sync” section to close DS1 Using a μ ohm-meter, measure the resistance of each pole by connecting the instruments between the input and output flanges.

The resistance readout must be: $R \leq 47 \mu\Omega$ for new apparatus For an already installed apparatus that has performed 5,000 operations or more, the resistance could increase up to $100 \mu\Omega$.

If the value measured is higher than the limit, it means that there are faults inside the poles.

Maintenance operations

Maintenance must only be carried out by ABB personnel.

Replacement of any parts included in the “List of spare parts/accessories” must only be carried out by ABB personnel.

8.7 Replacement due to System malfunctions

Contact the ABB personnel for assistance if the system functions in a faulty way.

The apparatus must be sent to the manufacturer’s factory if the following parts must be replaced:

- Complete pole with bushings/connections
- Motors.

Electronic devices, capacitor and cabling can only be replaced on site by ABB specialized field service technicians.

8.8 Spare parts and accessories



Assembly of spare parts/accessories regarding the installation, putting into service, servicing and maintenance must only be carried out by ABB personnel or trained personnel familiar with DS1 characteristics and Integration features.

Before performing any operation, check that the apparatus is open and that there is no voltage (medium voltage circuit and auxiliary circuits).

Installation of spare parts is part of field service. Replacement of parts due to system malfunctions must be performed by ABB service operators (at least Level 3).

If DS1 reports a fault, identify the type of fault as described in fig. 12 and contact ABB.

To order accessories or spare parts, please refer to the commercial ordering codes given in the technical catalogue and always indicate:

- Apparatus type
- Rated voltage of apparatus
- Rated thermal current of apparatus
- Serial number of apparatus

Please contact our Service department if field service or spare parts are required.

Annex A - Terminal Block for auxiliary control circuit

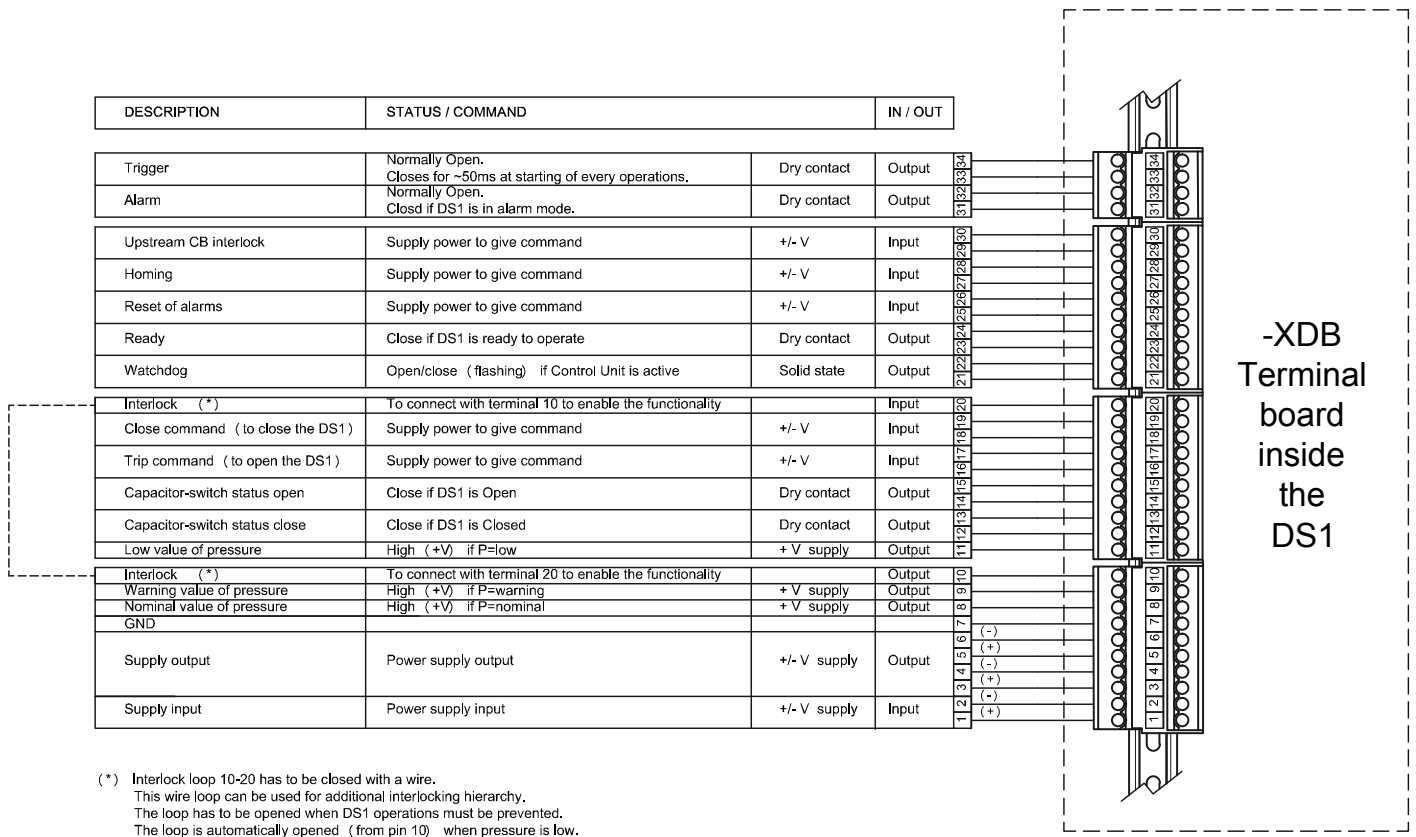


Figure 27. DS1 Terminal block for auxiliary control circuit

Annex B - External drawing for DS1 Integration

B.1 Overall dimensions

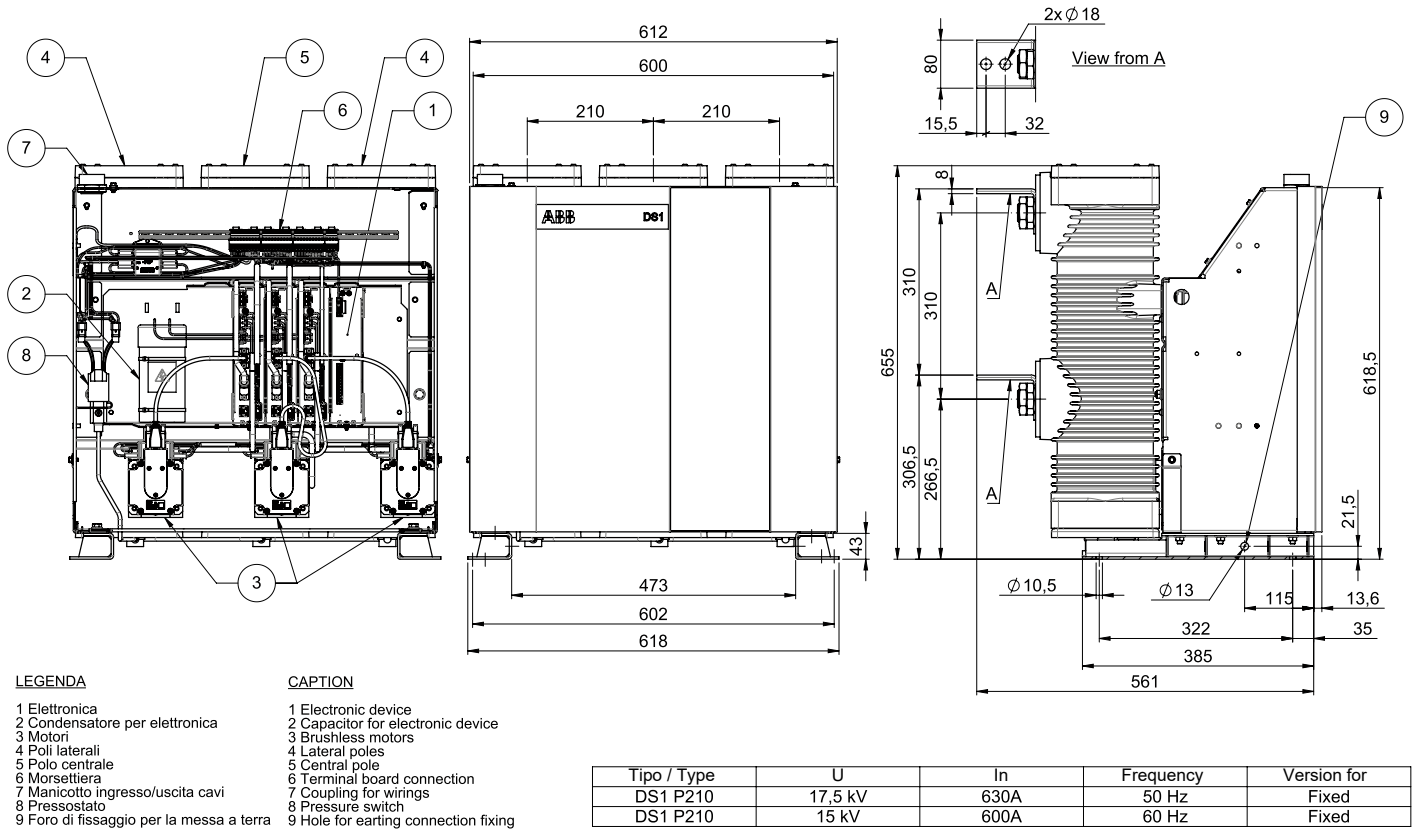


Figure 28. External drawing for DS1 integration (dimensions in mm)

B.2 Internal connections

For the internal circuit diagram, refer to the official circuit diagram provided with the apparatus or ask for support from your ABB sales representative.

For more information please contact:

ABB S.p.A.

**Power Products Division
Unità Operativa Sace-MV**

Via Friuli, 4

I-24044 Dalmine

Tel: +39 035 6952 111

Fax: +39 035 6952 874

E-mail: info.mv@it.abb.com

ABB AG

Calor Emag Medium Voltage Products

Oberhausener Strasse 33 Petzower Strasse 8

D-40472 Ratingen D-14542 Glindow

Phone: +49(0)2102/12-1230

Fax: +49(0)2102/12-1916

E-mail: powertech@de.abb.com

www.abb.com

The data and illustrations are not binding. We reserve the right to make modifications following technical developments to the product.

© Copyright 2015 ABB.
All rights reserved.