TYPE QS-DLS™ HV Dual/Multi-Voltage Switches (up to 230kV):
SCOPE:
This document contains general information about applying and installing the QS-DLS™ HV non-metallic rack and pinion driven de-energized dual/multi-voltage switches. These instructions do not describe all possible issues that may arise during installation, operation, or testing of the switch. It also does not describe all of the details and variations of the equipment. Consult the drawings supplied with the order for additional information. In addition, if there is a special application, the switch may be adaptable or customized in some aspects, so please contact Quality Switch for special requests.

INTRODUCTION:
The type QS-DLS™ switch is one family of the Quality Switch offerings that is designed for power transformers. An HV dual-voltage or multi-voltage switch is intended to be connected to the HV winding of a transformer. When the switch is moved from one position to another, the amount of the winding connected into the circuit is changed in order to vary the HV rating of the transformer. This type of switch varies from the typical DETC because typically the transformer line end voltages are present on the switch (unlike a DETC which is typically only a small percentage of the winding). The QS-DLS™ HV dual/multi-voltage switch can have all three phases in one group or be split into modular switch decks and connected to an external operating mechanism. This document will outline some common methods, but these designs can be adapted to meet many different configurations. The switch is designed to be mounted and secured to transformer super-structure (made of insulating wood or insulating pressboard) built up around the core and coil assembly of the transformer. The switch decks can be mounted shifted slightly off center of the core and coil assembly which allows the switch leads to be short and avoid long routing of the cable, or the switch can be mounted on top of the core and coil depending on the HV lead routing. Figure 1b shows the connection type most commonly used, but many others are available and can be adapted using the modular switch design or grouping multiple switches together to compensate for connections of uneven-series multiple switches.
Figure 1a: Mounting Arrangement Examples

Figure 1b: Typical 2:1 series-parallel Connection Diagram

<table>
<thead>
<tr>
<th>CONNECTION DIAGRAM</th>
<th>POSITION</th>
<th>CONNECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSITION</td>
<td>1/A (PARALLEL)</td>
<td>1-3, 2-4</td>
</tr>
<tr>
<td></td>
<td>2/B (SERIES)</td>
<td>2-3</td>
</tr>
</tbody>
</table>
RATINGS:
The QS-DLS™ HV dual/multi-voltage switches are available with a current rating of 1000amps per group or 500amps per group. The largest switch is typically used on transformers rated up to 230 kV. The switches can be applied on various BIL ratings if a specific winding arrangement falls within the design limits of the tested values between contacts on the switch. These are evaluated on a case by case basis. In addition, the ratings are dependent on how the switch is applied to the transformer, i.e. distance to the tank wall and distance between phases. Consideration must be taken to provide adequate clearance to the live parts (see Figures 2a/2b).

There are four basic construction types of the QS-DLS that are used in various HV applications. There could be some overlap in applications of the switches, but typically if the actual voltage ratings of the transformer are known and a transient analysis is done to determine the voltage requirements between the contacts, we can use that information to fit the best switch model to the application. The following table will summarize the maximum withstands tested between contacts for each switch model. These levels are the last passed values before failure occurred, so when ratings are applied to the switch, we will de-rate these numbers to add margin onto the last passed values. (Model 1 being the smallest and Model 4 being the largest).

Table 1:

<table>
<thead>
<tr>
<th>QS-DLS™ HV DV/Multi-Voltage Switch: Model 1 (smallest)</th>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW Impulse between contacts (1.2X50 µs)</td>
<td>Passed 3 tests (3-)</td>
<td>415 kV</td>
</tr>
<tr>
<td>60 Hz. Applied Voltage between contacts</td>
<td>140 kV for 5 minutes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QS-DLS™ HV DV/Multi-Voltage Switch: Model 2</th>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW Impulse between contacts (1.2X50 µs)</td>
<td>Passed 6 tests (3-,3+)</td>
<td>550 kV</td>
</tr>
<tr>
<td>60 Hz. Applied Voltage between contacts</td>
<td>185 kV for 5 minutes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QS-DLS™ HV DV/Multi-Voltage Switch: Model 3</th>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW Impulse between contacts (1.2X50 µs)</td>
<td>Passed 6 tests (3-,3+)</td>
<td>650 kV</td>
</tr>
<tr>
<td>60 Hz. Applied Voltage between contacts</td>
<td>240 kV for 5 minutes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QS-DLS™ HV DV/Multi-Voltage Switch: Model 4 (largest)</th>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW Impulse between contacts (1.2X50 µs)</td>
<td>Passed 6 tests (3-,3+)</td>
<td>925 kV</td>
</tr>
<tr>
<td>60 Hz. Applied Voltage between contacts</td>
<td>360 kV for 5 minutes</td>
<td></td>
</tr>
</tbody>
</table>
RATINGS (continued):

The QS-DLS™ HV dual/multi-voltage switches share some common components that are adapted into a scalable design. All of the models share the same basic operating characteristics for operating torque, temperature rise, and short circuit withstand. Table 2 below outlines these two different ratings that apply to all four models.

Table 2:

<table>
<thead>
<tr>
<th>QS-DLS™ HV DV/Multi-Voltage Switch (1000 amp)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Result</td>
</tr>
<tr>
<td>Temperature Rise in oil @ 1000amps</td>
<td>14 degrees C</td>
</tr>
<tr>
<td>Short circuit withstand (2 seconds)</td>
<td>15.1kA RMS, 26.72 kA peak</td>
</tr>
<tr>
<td>*Typical Operating Torque (3 phases)</td>
<td>≤ 25 ft-lbs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QS-DLS™ HV DV/Multi-Voltage Switch (500 amp)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Result</td>
</tr>
<tr>
<td>Temperature Rise in oil @ 500amps</td>
<td>9 degrees C</td>
</tr>
<tr>
<td>**Short circuit withstand (2 seconds)</td>
<td>9kA RMS, 12.5 kA peak</td>
</tr>
<tr>
<td>*Typical Operating Torque (3 phases)</td>
<td>≤ 12 ft-lbs</td>
</tr>
</tbody>
</table>

*Typical Operating torque listed is measured on a workbench. Mounting the switch assembly to a transformer structure may increase the operating torque measurement, but caution should be taken to avoid putting the switch mechanism in a bind due to mechanical mounting stresses.

** Short circuit withstand listed for 500amp is a calculated value and is based off of similar designs that have been validated thru testing.
DESIGN FEATURES & DETAILS:
The QS-DLS™ HV DV/Multi-Voltage Switch is assembled with basic components shown in Figure 2a and Figure 2b:

Figure 2a: Switch features

- 1000 AMP, 138kV X 69kV RECONNECTABLE 3 PHASE ALL IN ONE SWITCH DECK SHOWN
- Mounting holes (top & bottom) attach switch to transformer structure (Non-metallic hardware must be used to fasten to the structure)
- Front contacts slide in the opposite direction of the back contacts to make connections. No contacts travel to extend out beyond the switch deck frame in either position.
- Silver Plated Stationary & sliding contacts. These contact parts are the only metallic components used in the switch. All other mounting and drive shafts are non-metallic. Large diameter parts are used to shape the dielectric field and limit stress.
- Non-Metallic Gear drive mechanism.
Figure 2b: Switch features

500 AMP, 115kV X 69kV RECONNECTABLE MODULAR DESIGN (ONLY 1 PHASE SHOWN MOUNTED VERTICALLY)

Customer connection points can be varied for ease of manufacturing. One hole bolt-on lug is shown with bolt cap shields shown to reduce dielectric stresses around bolts.

Non-Metallic shafting and pins are used to couple together each phase.

Bolt-cap shield (2 per connection) folded over after connection is secured. CAUTION: Do not open and close bolt-cap more than 3 times as fatigue may cause it to break loose.

Cable Terminal is only a representation (not supplied by QS). Ensure leads are pre-formed and supported to minimize mechanical stress on the switch.

1/2"-13 Hex Bolt
1/2" Bellville washer
1/2"-13 Brass Jam nut (Not supplied unless specified with order)
NOTE: All four options are assembled in a manner that does not constrain the rotational motion of the connection points. Care will need to be taken to ensure leads are run to the switch in a manner to minimize mechanical stress on the switch connection. It is recommended for these connections to then be wrapped in some form of insulation (crepe paper or aluminum backed crepe paper) to aide in shielding sharp edges. Each customer may have a preferred method they use within their transformer on crimped, bolted, or threaded connections appropriate to the voltage class. Specify the preferred connection option when ordering your switch.
SWITCH DECK MOUNTING BOARD:
The QS-DLS™ HV switch deck, mounting supports, and non-metallic rack & pinion drive mechanism are machined of a high pressure laminate and oil impregnated nylon that are specifically tested for high voltage applications. The stationary contacts are assembled onto the laminate board with the portion that touches the moving contact being silver plated for contact stability. This stationary contact is also machined with a full radius on the end to provide a nice dielectric shape for shielding the contacts. The customer connection end can be crimp connections (size of crimp specified by customer), single hole bolt-on connection, two hole bolt-on connections, or a 5/8”-11 threaded post with brass shields for the switch lead terminal (see Fig. 2b & 2c). The rotational motion of these connectors is not constrained by the mounting support. Each switch deck assembly is typically supplied with several mounting locations to fasten the switch deck to the transformer structure (see outline drawing for details). For switches with modular switch decks, the assemblies are then coupled together with insulating drive tubes and fiber pins/nuts to chain multiple phases together.

SLIDING CONTACT:
The QS-DLS™ HV switch sliding contact is a silver plated solid copper contact that has a fully rounded contact edge to avoid sharp edges and provides a line type contact with the stationary terminal which in turn allows a relatively low operating torque. The sliding contact is spring loaded to provide ample contact pressure to withstand blow-off forces under fault conditions. The contact is fastened to the non-metallic rack and pinion drive using a fiber rod. The insulating drive shaft of the switch will typically rotate 360 degrees for one position change. This operation of the switch creates a sliding action that wipes the contact surfaces of the moving and stationary contacts.

OPERATING MECHANISM (main drive shaft and external mechanism):
The external operating mechanism couples to an insulating tube that is attached to the non-metallic rack and pinion drive mechanism on the front switch deck. The rack and pinion mechanism is driven from a fiber shaft that extends from the switch deck that will have a hole or holes to couple with the insulating tube (see final outline drawing for details). There are few different front drive options. One is a spring loaded coupling assembly. This coupling is supplied assembled to a mounting plate and handle assembly shown in Figure 3a. This mounting flange will attach to a flange that is welded to the transformer tank (typically on top of a pipe header) and will require a gasket seal. This flange and gasket are not supplied by QS. The handle follows a Geneva index plate and rotates 360 degrees for each position change.
Figure 3a: Spring loaded operating mechanism

Ensure Handle and switch are in the same position before coupling together (Geneva Position Plate Wheel requires 360 degree rotation).

Spring loaded coupling with mounting plate & handle assembly (supplied assembled with handle, position plate, mounting plate with O-ring seal, and shaft complete by Q.S.).

Mtg. plate bolts to flange with sealing gasket (flange & gasket by customer).

Pad locking hole for Handle (3/8" dia. shackle).

Front Insulating Drive tube.

Shaft & Pin that couple with spring loaded assembly.
OPERATING MECHANISM (main drive shaft and external mechanism):
Another option for the front drive mechanism also uses a mounting flange, but instead of the spring loaded coupling, this option uses a slotted insulating tube. This assembly couples with the fiber gear shaft after tanking and will require access to the switch. Typically if mounted on top of the transformer assembly, there is good access until the cover is installed. If the unit is modular and vertically mounted alongside the core and coil, an access panel may be required to join the two shafts. The slotted drive tube is attached using a fiber pin with threads on each end that use non-metallic nuts to secure the pin in place. See Figure 3b for general details of this operating mechanism.

Figure 3b: Slotted Insulating drive tube operating mechanism
OPERATING MECHANISM (main drive shaft and external mechanism):
Another option for the drive mechanism is available with a handle and mounting arrangement that requires the sealing boss be welded directly to the tank. This method uses a flexible steel coupling on the end of the insulating drive tube to be coupled with a brass shaft that will have a pin. This brass shaft will then be inserted thru the tank wall (from the inside) and sealing mechanism typically before tanking. The handle will then fasten to the shaft with a pin. This method requires four mounting posts be welded to the tank in a pattern to secure the position plate. After tanking, the brass shaft is then pushed into the steel coupling on the end of the insulating switch tube. This step may require access to the coupling to hold in place as the shaft is installed. The components can be seen in Figure 3c (all components are supplied packaged loosely in with the switch).

Figure 3c: Flexible steel slotted drive coupling mechanism
OPERATING MECHANISM (interphase drive tubes and couplings):
For the modular switch type with more than one switch deck, the operating mechanisms that attach the other decks together are done by connecting slotted insulated drive tube couplings to a smaller tube that is fastened to the fiber shaft on the non-metallic gear drive shaft. This insulating tube is slotted and has an oversized inside diameter to accommodate some minor misalignment between each deck assembly. After the tubes are installed, they are fastened together using a non-metallic fiber drive pin and nuts.

Figure 4a: Insulating tubes
Figure 4b: Alignment Pins for installation

Ensure all switch decks are in the same position before coupling them together or installing the handle shaft.

1/8” diameter alignment pin is typically tagged and supplied with the switch in the parallel position. REMOVE PIN BEFORE OPERATING THE SWITCH.
HANDLING, INSTALLATION AND MOUNTING:

Receiving the Type QS-DLS™ EHV DETC:
- Upon receiving the type QS-DLS™ HV DV/Multi-Voltage Switch, check for visible damage. Notify Quality Switch if any damage is found.
- For Modular switch decks, they shipped with the contacts in the same position. These may shift during shipping, so ensure each switch deck sliding contacts are all in the same position before assembly (an alignment pin can be used to ensure all contacts start in the same position—see Figure 4c.). For switches with all three phases on one switch deck, they too will be shipped with an alignment pin to hold the position when coupling with the handle.
- Verify that the shipment is complete and contains all loose components. Several smaller components (i.e. handle assembly, insulating drive tubes, bearing plate, fiber pins, nuts, etc.) will be wrapped individually for protection during shipping and marked with a yellow sticker that states ‘Parts Enclosed’, so take caution not to discard them with the packing material in the container. These components will be listed in the description of the item on the packing list provided with the shipment.
- Check that the packing list matches the order numbers and part numbers included on the order acknowledgement. A serial number will be engraved on each switch deck mounting board that should correspond with the sales order number found on the order information.

Preparation required by Customer:
- Prior to installing the switch, appropriate mounting in the transformer tank is required. A mounting flange with the appropriate bolt pattern and gasket seal is required to be welded (gas tight) to the transformer. The mounting flange and pipe header are not supplied by QS. For the sealing gland described in Figure 3c, the steel gland will be welded directly to the tank. The appropriate dimensions and specifications will be included on the outline and/or detail drawings of the switch.
- The transformer structure needs to be prepared with holes appropriate for mounting the type QS-DLS™ HV switch deck(s). The hole patterns are also shown on the switch outline drawing. Hardware to secure the switch to the structure is not supplied with the switch, but can be ordered separately if required. This must be non-metallic hardware.
- Only standard tools are required for installation.
Mounting:

- The type QS-DLS™ HV DV/Multi-Voltage switch requires a support structure constructed of appropriate insulating material to secure the switch deck mounting boards. The switch decks (when 3 modular phases) are typically mounted in a vertical manner and secured using the holes on each end of the switch deck. If one switch deck for all 3 phases is supplied, the switch is typically mounted horizontally on top or out in front of the coils on the transformer structure. The structure is typically the same structure that supports the HV leads in the transformer design. Also, support may be required for the front insulating tube using a bearing plate provided by QS. This bearing plate can also be secured to the same structure and is used to avoid the cantilevered load on the insulating tube from the front switch deck. A cradle type support can also be fabricated out of the transformer structure to accomplish the same support for the drive shaft (care must be taken to avoid putting the shaft in a bind with the support).
- Refer to the switch outline drawing for specific mounting dimensions for your switch.
Installation Steps (in general):

1) Make sure that all of the switch decks are in the same position (the moving contact should align on all of the switch deck assemblies). The switch decks are typically shipped in the parallel position, but they may shift during transit. Rotate the drive shaft to align all the moving contacts if they have moved and verify using an alignment pin (see Figure 4b).

2) Install the first deck by inserting fiber threaded rod or bolts thru the supplied mounting holes in the switch deck and secure the switch deck to the transformer structure with non-metallic nuts. These holes need to be slightly oversized to avoid forcing the bolts into the holes.

3) To mount the second switch deck, also install the threaded bolts into the holes on the switch deck mounting boards and slide them thru the transformer structure. However, do not snug up the nuts that will secure the board to the transformer structure and allow it to be loosely held in place.

4) Install the insulating drive tube between the first and second switch deck by sliding the coupling tube over the insulating shaft already attached to the fiber Geneva drive shaft. Install the supplied threaded pin thru the slot and attach non-metallic nuts to each end of the pin to secure the coupling (see Figure 4a.).

5) Repeat the process for the third switch deck.

6) To confirm that the installation has been done properly, after tightening all mounting hardware, be sure to remove the alignment pin(s) from the switch and turn the operating shaft and observe the movement of the sliding contacts on all three deck assemblies. All three phases should move together in a synchronized fashion.

7) Connecting leads to the switch deck assemblies is dependent on the connection method (specific to order). The leads should be pre-formed and arranged to not apply any mechanical stresses to the switch deck or switch assembly (see Figures 2b & 2c).

8) It is recommended for these connections to then be wrapped in some form of insulation (crepe paper or aluminum backed crepe paper) to aide in eliminating sharp edges. Each customer may have a preferred method they use within their transformer on crimped, bolted, or threaded connections appropriate to the voltage class.
9) After the drying out process all non-metallic hardware will need to be re-tightened. Snug up non-metallic nuts finger tight (5-8 ft-lbs) similar to all the other non-metallic hardware on the transformer structure. Then apply electrical epoxy (i.e. Glyptal or equivalent) to prevent them from vibrating loose.

10) The insulating shaft between the front switch deck and the handle operating mechanism external to the tank are coupled together after the core and coil assembly have been installed into the tank. A bearing support (when required) shall be provided by QS to be installed near the end of the tube to prevent deflection and keep the insulating tube aligned with the hole in the tank after tanking. Several different options are available for the operating mechanisms (see Figures 3a thru 3c). All methods are designed to compensate for minor misalignment and minor variations in expansion and contraction. If the shafts are jammed together after installation and restrict operation of the switch, re-fitting may be required to better align the drive shafts of the switch.
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CONTACT QUALITY SWITCH:
TELEPHONE: 1-330-872-5707
FAX: 1-330-872-3664
EMAIL: sales@qualityswitch.com
www.qualityswitch.com