De-energized tap changer, type DTW
Technical information guide
Scope
This guide contains general information for ordering and installing the type DTW de-energized tap changer. This guide does not describe all possible contingencies, which may arise during installation, operation or maintenance of the tap changer, nor does it describe all details and variations of the equipment. If you require additional information regarding the installation and the operation or maintenance of your equipment, please contact ABB.

Safety definitions
Safety notations are intended to alert personnel of possible conditions, which may cause personal injury, property damage or even death. They have been inserted into this instructional text prior to the step in which the condition is cited. The safety notations are headed by one of three hazard intensity levels, which are defined as follows:

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**DANGER**
A DANGER symbol indicates a hazardous situation which, if not avoided, will result in death or serious injury.

**WARNING**
A WARNING symbol indicates a hazardous situation which, if not avoided, could result in death or serious injury.

**CAUTION**
A CAUTION symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
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Introduction

The type DTW de-energized tap changer is one of a family of ABB tap changers for power transformers. The type DTW switch can also be configured to perform series/parallel switching, dual voltage switching and delta-wye switching. This manual describes the tap changing features of the type DTW switch. If you require information regarding other forms of switching, please contact ABB.

A de-energized tap changer is a switch connected to the winding taps of a transformer. When the tap changer is moved from one position to another, the amount of the tap winding connected into the circuit is changed. This permits the adjustment of the voltage ratio of the transformer to best suit the voltage requirements at the transformer’s installation site. The de-energized tap changer is usually installed into the high voltage circuit of the transformer and, most of the time, it is used to adjust the primary voltage of the transformer within a ±5 percent range in four steps.

The type DTW tap changer is a modular, bridging-type (zigzag) tap changer with an external operating mechanism. It is most commonly available as a 5-position device. Other configurations are available or can be designed; for these, please contact ABB. The type DTW tap changer is made up of individual tap decks (one or more per phase). The tap deck is the fundamental component of the tap changer. The tap deck holds and orients both the moving and stationary contacts and provides the connection point for the tap leads from the winding. These components are mounted on the winding side of the tap deck. The phase tap decks are connected to a common set of horizontal operating shafts through individual gear sets. The gear sets and operating shafts are mounted on the tank wall side of the tap deck. The tap changer is mounted in front of each phase coil, parallel to the side of the transformer tank. The tap changer is supported by an insulating framework, which is part of and attached to the transformer superstructure. See Figure 1 for a general view of a type DTW tap changer installation. The ability to locate the type DTW tap changer on the side of each phase coil permits very direct tap lead routing with a minimum of bends.

All materials used in the construction of the type DTW tap changer have been chosen for their superior electrical properties, mechanical strength, temperature extremes capability, corrosion resistance, transformer oil compatibility and light weight.

DANGER

Never operate the type DTW de-energized tap changer when the transformer is energized. Operation when the transformer is energized is dangerous and will result in severe personal injury, property damage or death.
Direction of rotation
The ABB convention for describing the direction of rotation of the type DTW tap changer is to view the rotation from the tank wall side of the tap deck. Figures 4 and 5 show the deck from the winding side of the DTW tap changer.

Ratings
The type DTW tap changer is available in one basic current rating and is offered with several different electrostatic shielding and insulation options. The table below presents the various rating options.

<table>
<thead>
<tr>
<th>Test parameter</th>
<th>Rated value</th>
<th>Reference dimension on tap changer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage class</td>
<td>See note 4</td>
<td>N/A</td>
</tr>
<tr>
<td>Phase to ground and phase to phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightning impulse</td>
<td>See note 4</td>
<td>N/A</td>
</tr>
<tr>
<td>Power frequency withstand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between adjacent contacts ²</td>
<td>180 kV</td>
<td>A-B, B-C</td>
</tr>
<tr>
<td>Lightning impulse</td>
<td>75 kV</td>
<td>D-E, F-A</td>
</tr>
<tr>
<td>Power frequency withstand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With contacts B and E removed ³</td>
<td>280 kV</td>
<td>A-C, C-D</td>
</tr>
<tr>
<td>Lightning impulse</td>
<td>110 kV</td>
<td>D-F, F-A</td>
</tr>
<tr>
<td>Power frequency withstand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short circuit current</td>
<td>10,000 A rms</td>
<td></td>
</tr>
<tr>
<td>Steady state current</td>
<td>665 A</td>
<td>10 °C</td>
</tr>
<tr>
<td></td>
<td>845 A</td>
<td>15 °C</td>
</tr>
<tr>
<td></td>
<td>1015 A</td>
<td>20 °C</td>
</tr>
</tbody>
</table>

1 See Figure 3: Schematic drawing, counter clockwise direction
2 Temperature rise over local oil temperature
3 Historically, Westinghouse used this tap changer at 1,000 A
4 The dielectric withstand from phase-to-ground and from phase-to-phase is very much dependent on the electrical clearance distances between the live, energized parts of the tap changer and grounded objects which are maintained by the transformer design.
5 For tap changers with configurations other than the standard 5-position or 2-position, please contact ABB.

Figure 3 — Front view, position 1 for CCW rotation | Figure 4 — Position 1, CW rotation | Figure 5 — Position 1, CCW rotation
Construction details and features

Basic information
The major subcomponents of the type DTW are:
- Tap deck
- Moving contacts
- Stationary contacts
- Mounting posts
- Worm gear
- Drive shaft
- Operating mechanism

Tap deck
The tap deck is a flat insulating plate and serves as the base to which all of the other tap changer components are bolted. The tap deck is bolted to the transformer framework through the six bolt holes, which are located at each end of the tap deck. The flat insulating plate is fabricated from high strength, electrical grade, low power factor phenolic-paper board. This structure carries all of the mechanical loads created by the weight of the tap leads and the thrust and weight of the drive shafts.

Contacts
The stationary contacts are 1/4 inch (6.4 mm) thick, silver-plated copper flats. The leading edges are chamfered to enable the moving contacts to easily slide up onto position. The stationary contacts are bolted to tin-plated, copper mounting posts, which in turn, are bolted to the tap deck. The stationary contacts are bolted to the mounting posts with two bolts. Special toroidal washers shield the bolt heads and washers to minimize electrical stress concentration.

The mounting posts serve as the connection point for the tap leads. The tap leads from the coil should be terminated with a two-hole flat connector. The flat connector is bolted to the mounting post with two 0.375 bolt sets. The mounting posts “capture” the bolt head so that only the nut has to be turned to tighten the joint.

The moving contact set is a “pincer” type of contact; the spring loaded contact plates slide over the stationary contacts (see Figure 6). Each contact plate is made from copper flat stock. The copper plates are tipped with semi-spherical, solid coined silver contact buttons. This alloy contact button assures a positive, low friction, low resistance current path at all times, even when taps are changed very infrequently. The sliding action of the contact buttons over the chamfered stationary contact creates a wiping action during the tap change, which further guarantees a solid, low resistance electrical contact. Two coil springs precisely control the contact force, which is set and calibrated at the factory to provide uniform and consistent contact force. The combination of contoured interface surfaces between the moving and stationary contacts and the accurately calibrated spring-loaded pincer contacts minimizes the force needed to drive the tap changer from one position to another. The pincer type of contact takes advantage of the magnetic attractive forces created during through faults or current surges. These additional compression forces yield high fault current withstand capability by preventing contact bounce and arcing during faults. These features permit the tap changer to have a relatively low driving torque, yet maintain a high through fault current withstand capability.
Worm gear set
The worm gear set is mounted to the tank wall side of the tap deck (Figure 8). Its function is to convert the rotary action of the driving shaft 90 degrees in order to turn the moving contacts from position to position. This gear is contained within a cast metal housing. The function of the housing is to position and hold the gear set and to provide a smooth, rounded corner enclosure in order to minimize electrical stress concentration. The nature of the gearing is such that one full turn of the drive shaft rotates the moving contacts from one set of stationary contacts to the next (30 degree rotation).

Driving system
The drive system consists of several parts: the worm gear drive, the inter-phase shafts, the main drive shaft and the operating mechanism.

The worm gear rotates the moving contact shaft. This gear is meshed with the worm driver, which is attached to the drive shaft through ball joints. The entire worm driver assembly is designed to provide positive drive shaft engagement with a minimum of backlash and maximum forgiveness of shaft misalignment. The worm driver terminates in a ball-shaped shaft end.

The inter-phase shafts are filament wound glass epoxy tubes. These shafts slide over the ball-ends of the worm gear drive shaft creating a ball-and-socket type of joint. Each inter-phase shaft consists of two pieces which telescope together. This telescoping action allows the tap changer to accommodate a range of phase-to-phase spacing and eliminates the need for precise, cut-to-length shafts. The telescoping action makes assembly easy, accommodates some misalignment and accommodates movement due to thermal expansion of the transformer.

The telescoping input drive shaft connects the external operating mechanism to the first tap changer deck. This shaft is also a filament wound glass epoxy tube. The combination of ball joint connectors and telescoping and slip-joint shaft tubes allows the drive mechanism to accommodate misalignment between tap changer decks and the operating mechanism. This combination also allows for any expansion and contraction that will occur as the transformer responds to temperature variations.

The operating mechanism (Figure 9) is sealed to the mounting boss by a flat gasket, which is retained by a machined groove in the flange of the mounting boss (sold separately). The operating mechanism is bolted to the mounting boss. The operating mechanism drives the tap changer’s operating shaft. Generally, one revolution of the operating mechanism moves the tap changer one position. However, there are applications, e.g., 3-position tap changer where more than one revolution is required to advance to the next position. In any case, the tap changer is on position when the tap number shows fully in the view port and the locking pin can be engaged.

To make a tap change, the operator must perform two separate actions: pull the locking pin, which frees the mechanism shaft and turn the operating handle. A geneva tap indicator dial is visible in the view port of the operating mechanism. The geneva tap indicator shows the number of the tap position. A position number is only fully visible when the tap changer is in position. The locking pin will not fully re-seat itself unless the tap changer is fixed on a position. The operating mechanism contains built-in positive mechanical stops, which prevent turning past the lowest and highest positions. The operating mechanism can be locked on any position (Figure 9). All external parts are made of low corrosive material.

Figure 8 — Worm gear | Figure 9 — DTW operating mechanism with locking provision (pad-lock not included)
Electrostatic shielding and insulation

Electrical spacing requirements between the tap decks and the tank wall and between the adjacent phases and/or other parts of the transformer are a complex subject. The transformer designer must calculate the required electrical clearance distances between phase decks and between phase decks and ground or other parts of the transformer. Three options of shielding are available for the tap decks.

Unshielded (Figure 10):
Tap decks do not have any electrostatic shields. This configuration is typically used for applications which have an impulse voltage withstand requirement of 200 kV or less.

Level 1 electrostatic shielding (Figure 11)
A cast-aluminum electrostatic shield ring is placed between the tap changer deck and the transformer tank wall. This ring is referred to as the “outer shield”. The ring is bolted to an aluminum mounting plate, which is, in turn, bolted to the worm gear housing. The ring portion of each shield is insulated with a layer of crepe paper wrap. This configuration is, typically, used for applications which require an impulse voltage withstand of 650 kV or less.

Level 2 electrostatic shielding (Figure 12)
Cast-aluminum, electrostatic shield rings are mounted on both the tank wall side and the coil side of each tap deck. The shield rings are wrapped with cotton tape. Both the inner and outer shield rings are bolted to the aluminum mounting plate, which is, in turn, mounted to the worm gear housing. The outer ring portion of each shield is a continuous ring. The inner shield consists of two half-circle rings.

In addition to the aluminum rings, a pressboard disk is placed in front of the aluminum mounting plate and a pressboard box shield is added to the tank wall side of each deck. The pressboard disk is attached to the aluminum mounting plate with cotton tape. The box shield is attached to the transformer support structure with cotton tape. This configuration is, typically, used for applications which require an impulse voltage withstand greater than 650 kV; the upper limit of impulse withstand in this configuration is determined by the electrical clearances designed into the transformer.

Standard configurations and the order data sheet
There are many configurations of the type DTW tap changer. The user must decide on one deck per phase or two decks per phase and the location of the operating mechanism relative to the drive shaft. The order data sheet describes these variations and allows the customer to select the combination that is required. The order data sheet also allows the customer to describe the technical requirements for any particular installation. Use the order data sheet to specify configuration, mechanism location, important spacing dimensions and electrostatic shielding requirements. ABB is unable to manufacture or accurately quote a DTW de-energized tap changer without a completed order data sheet. Budgetary pricing is available upon request, but should be confirmed prior to order submittal.
Installation

Inspection upon receiving

Before opening the shipping crate, check for any obvious signs of damage or poor handling. Open shipping crate and closely examine the tap changer components for any sign of damage.

ABB ships all DTW tap changers with the moving contacts shown on position “1”. Check to verify that the moving contacts are indeed in this position before continuing.

Verify that the shipment is complete and contains all components ordered.

Check that the type designation and shop order number agree with the delivery documents (i.e. the packing list or ABB’s order acknowledgement). The shop order number is hand-written on the top edge of the tap deck.

Required tools and materials

- Wrench with 9/16-inch hex socket — for connection of leads to the tap deck and for assembly of the aluminum shield casting
- Screwdriver with flat head — used together with 9/16-inch hex socket wrench in assembly of aluminum shield casting
- Two wrenches with 3/4-inch (19 mm) hex socket — for tightening bolt and nut on operating mechanism

Pre-installation work required by customer

Make the appropriate size hole in the transformer tank according to the dimensions shown in the tap changer outline drawing. In addition to the hole required to accept the mounting boss and operating mechanism, a hand hole may be required in this vicinity to allow the final mechanical connections to be made between the operating mechanism and the drive shaft.

Weld the mounting boss/bosses (not supplied by ABB) to the transformer wall. These welds must be gas-tight.

Prepare the transformer superstructure with holes for the assembly of each DTW deck. The common installation feature, regardless of other options chosen, is that each deck of the DTW tap changer mounts to the transformer superstructure with six glass-fiber bolts. There are usually one or two DTW decks installed per phase depending on the design of the transformer.

Deck serialization

ABB assembles and mechanically tests all tap changers prior to shipment. You should install the tap changers in the same location sequence as these tests were performed. Each deck has three sets of numbers written on its top edge (see Figure 13). Mount the deck noted as number 1 in the first position closest to the operating mechanism; mount the deck noted as number 2 in the next position and so on. If you are assembling a double deck tap changer, arrange the decks so that the decks numbers 1, 2 and 3 are all in the lower row and the decks marked 4, 5 and 6 are in the upper position with deck 1 immediately below deck 4.
Deck installation

Use the following steps to install a DTW tap changer:

1) Remove each tap deck from the shipping crate and verify that it is on position number “1”.

2) Loosely bolt each tap deck onto the transformer superstructure once the mounting holes of the superstructure have been prepared. Each tap deck requires six glass-fiber bolts and twelve glass-fiber nuts to attach the deck to the transformer superstructure (glass-fiber hardware not included).

3) Bolt the tap leads to the appropriate mounting post on the tap deck (according to the transformer specification). This connection requires a flat connector on the end of the tap lead. The center line spacing of the bolt holes on the mounting post is 1.0 inch (see Figure 7 for mounting post dimensions). Fasten each lead to its mounting post with (2) 3/8 inch bolts (hardware not included). Locate the mounting bolt so that the bolt head is on the internal side of the copper mounting post. The recess on the internal side captures the head of the 3/8 inch bolt and prevents the bolt head from rotating during the tightening process. Each tap lead requires two mounting bolts, two flat washers, two cup-washers, two lock-washers and two nuts (see Figure 15).

4) Tighten the (6) glass-fiber nuts to secure the deck to the transformer superstructure.

5) Assemble the inter-phase drive shaft to the worm gear’s ball-end fitting. Align the slot in the shaft with the hole in the ball end fitting. When this is done, place a spacer ring into the hole; this ring should ride in the groove of the ball end fitting. Bolt this assembly together using the prevailing torque bolt and hardware that is provided (see Figure 16).

6) Install any remaining decks by repeating steps 3-5.

7) Mount one half of the drive shaft to the left end or right end tap deck as specified on the transformer drawings in the same manner as shown in Figure 16.

8) If electrostatic shielding kits are to be used, they should be mounted at this time (see section on Shield kit installation).

9) After the core and coil is tanked, assemble the second half of the drive shaft to the ball end fitting of the operating mechanism. Join the two halves of the operating drive shaft before attaching the operating mechanism to the mounting boss. Reference Figure 14 to attach the operating mechanism to the mounting boss.

Figure 15 — Tap lead installation | Figure 16 — Shaft installation for DTW tap changer
**Shield kit installation**

**Level 1 shield kit:** To install a Level 1 shield kit, bolt the crepe paper wrapped aluminum shield casting and the aluminum-mounting disk to the worm gear housing with the three bolts provided in the kit (see Figure 17).

For Level 1 and Level 2 shield installation, make sure that the top mounting bolt holding the aluminum casting to the gear housing does not make contact with, nor interfere with the gear (see Figure 18).

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**Figure 17 — Level 1 shield installation**

**Figure 18 — No interference is allowed between the worm gear and the mounting bolt.**
**Level 2 shield kit:** To install a level 2 shield kit, bolt the aluminum mounting disk to the worm gear housing using the provided hardware as seen in Figure 19.

Place the outer continuous ring shield in position and then place the inner half-circle ring shields in position. Both the outer ring and the inner half-circle rings are bolted to the cast aluminum-mounting disk with the provided hardware as seen in Figure 20.

Use cotton tape to attach the pressboard disk to the aluminum mounting disk (see Figure 12). Finally, use cotton tape to attach the box shield to the transformer superstructure (Figure 21).

After the drying and impregnation process of the core and coil make sure the glass fiber nuts holding the tap decks to the superstructure are re-tightened according to the transformer’s specifications. The mounting bolts used to attach the mounting posts and worm gear housing should also be re-tightened (see Figure 23). The section Processing Temperatures goes into more detail regarding the heating and drying of the DTW tap changer.

Before placing the core and coil into the tank, verify that all tap decks are set to Position “1”. Position the main drive shaft at the correct height so that it is aligned with the hole in the mounting boss. Use a length of cotton tape (or similar material) as a sling to assist in this alignment process. Once you have properly aligned the drive shaft tie the cotton tap sling to the superstructure to temporarily hold the shaft in place.
Double deck set-up
An additional gear box is needed when the transformer has two rows of tap decks or whenever the operating mechanism is not in line with the deck. The additional gear box is mounted in the same manner as the operating mechanism. The internal drive shaft coupled to the additional gear box is mounted in the same manner as was described in the section “Deck installation”.

Figure 22 depicts the installation of a double deck with the additional gear box located above the operating mechanism. The connecting shaft assembly between the operating mechanism and the additional gearbox allows the external mechanical connections to be made without moving the position setting of the internal tap decks. The external shaft connections have enough “universal joint” movement to overcome about seven degrees of misalignment between the additional gear box and the operating mechanism. The vernier coupling allows installation and adjustment of the connecting shaft without disturbing the tap changer settings within the transformer.

After installing the operating mechanism, additional gear box, DTW decks and shafts, use Figure 22 and the appropriate assembly drawing to couple the operating mechanism to the additional gear box. 
1) Place the half of the rotary vernier coupling with the spherical drive end on top of the other half.
2) Determine the dimension, K1, between the spherical drive ends.
3) Cut the square vertical drive shaft to a dimension that is 6 mm less than K1. Remove all burrs.
4) Fit the two halves of the square coupling onto either end of the square shaft with the six bolts and washers provided.
5) Connect the square shaft end with the mounted square coupling to one of the spherical drive ends of the operating mechanism or the gear box.
6) Fit the two halves of the other square coupling onto the other end of square shaft with the six bolts and washers provided and connect to the other end of the spherical drive shaft.
7) At this point, the vertical drive assembly should be snug but with enough play to allow about 2 mm of vertical movement. Once you have the shaft properly aligned, fully tighten the bolts joining the split square couplings.
8) Adjust the vernier coupling to maintain the correct rotational alignment between the upper gear box and the operating mechanism.
The type DTW tap changer is designed to operate properly in the transformer environment. However, the transformer manufacturer must not over stress the tap changer, thermally, during transformer manufacturing and processing. The maximum temperature that the type DTW tap changer can be exposed to during transformer manufacturing is 125 °C. If the tap changer will be exposed to temperatures greater than 125 °C, ABB should be consulted for technical guidance.

Processing within the temperature range of 105 °C to 125 °C should not exceed 48 hours of total exposure time. During processing make sure that the tap changer is not subjected to thermal shock by the hot vacuum processing fluid (temperature gradient should be less than 10 °C / hour).

Figure 23 — After vapour phase and drying, re-tighten the bolts that attach the mounting posts (left) and the worm gear housing (right) to the deck.

(12) Mounting post bolts (tank side)

(3) Worm gear mounting bolts (winding side)
WARNING

Before attempting any disassembly or repairs, de-energize the transformer. Failure to do so could result in personal injury, property damage or death.

Maintenance and repair

ABB de-energized tap changers require little or no maintenance to ensure proper mechanical and electrical operation of the switch. Always de-energize the transformer before operating the tap changer. Inspect the operating mechanism for any damage. Lubricate the ball joint connector which is inside each of the split square couplings (see Figure 22). Any time that you operate the tap changer, you should cycle it through its entire range a minimum of 20 times before setting it onto the desired tap position. The tap changer’s operating mechanism housing and additional gear box (if present) is lubricated for life and should not be disturbed.

Repairs

In normal use, the DTW tap changer will not require any repair. We recommend that you contact the manufacturer before making any repairs.

Renewal parts

If renewal parts are required, order them through the nearest ABB representative. Please provide the item description and the identification numbers (model, style, catalog number) from the unit’s nameplate.

Technical support

If a technical question arises regarding the product detailed in this document contact ABB.